Water Works and Sewerage

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Putting Down the Piling for the Cofferdam for the Cherry Creek Crossing

Denver Installs New Water Conduit

Construction Features of New 8-Mile 60-In. Pipe Line That Will Cost $1,300,000

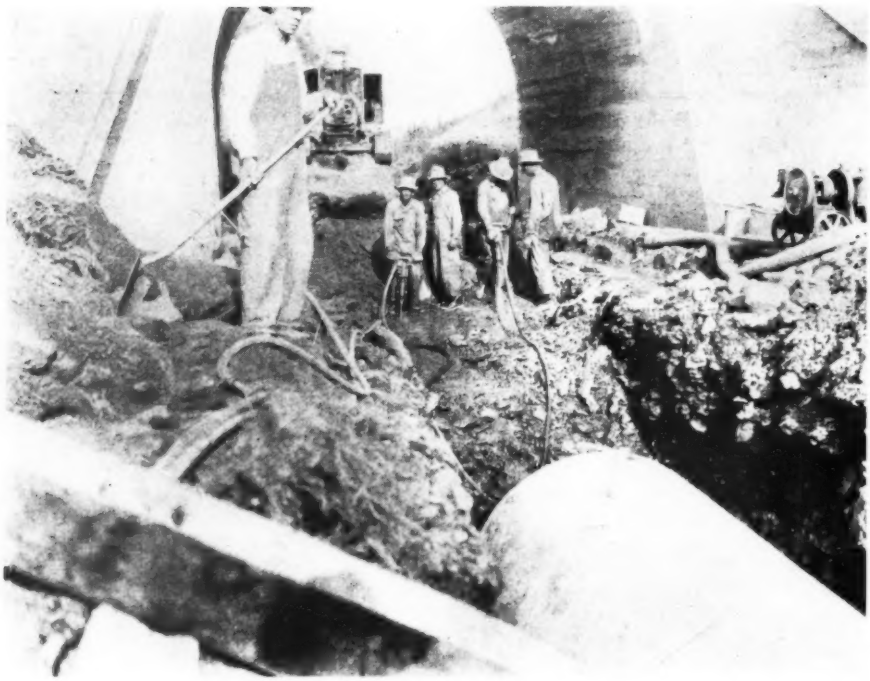
By JOS. C. COYLE

THE latest improvement in Denver's $23,000,000 water works system is nearing completion at this writing and will help carry the peak of the 1930 water consumption. This is an 8-mile installation of 60-in. reinforced concrete conduit connecting the Capitol Hill pumping station with Wynetka Junction. From the university park station to the Capitol Hill station it replaces a 20-year-old 48-in. conduit, partly of wood and partly of steel. The purpose of the line is to augment the water supply brought in by other conduits from filters near Wynetka. The total cost of the line is $1,300,000.

A number of adverse conditions along the line of construction, swamps, hard rock, two river crossings and a mile of frozen ground that had to be blasted to a depth of 3 to 5 ft., made the installation an interesting and difficult one. Several hundred yards of swamp just west of the Platte River gave considerable trouble, both in timbering and water removal. The first was overcome by the use of a heavy unit of shoring to hold the banks while sections of the pipe were installed. This shoring was placed and removed as the work progressed by the machine used for excavating. A large scraper, operated by the same machine, backfilled the trench after a stretch of the pipe was laid.

The water problem was solved by the use of three extra 5-in. centrifugal pumps, direct connected to used automobile engines for power. The frames only were used with these engines, being cut down in length with acetylene torch and braces welded on by which to lift the outfits with a crane.

Pull shovels were used in excavating by the two construction crews, one doing both excavating and laying of pipe while a crawler crane placed the pipe and back filled for the second crew. The width of the trench was usually 8 ft., and the depth from 9½ to 15 ft. At the crossing of the Platte River a cofferdam of interlocking steel piling 18 ft. wide and 103 ft. long was driven to bedrock and the gravel removed from the inside, while two of the large centrifugal pumps kept the seepage water under control. The bed rock of blue serpentine was drilled and blasted to a depth of 8 ft. The pipe was laid for the length of the cofferdam, being drawn together with a chain attached to a steel bar across the back end of each joint, and to a hand wheel at the front end, while the section was suspended on a wire cable and manipulated by a small block. The pipe was covered with concrete to a depth of 2 ft., the 103 ft. section was



Rock Excavation at Railroad Overhead Crossing

backfilled and the operation repeated twice, making the total length of the river crossing 309 ft.

Two railroads and a highway, near the Platte River crossing, were crossed through concrete culverts in a small ravine. The three culverts were near each other and at this point the excavation was almost entirely in sandstone, necessitating blasting. Two drills were operated from a portable compressor. The holes were slanted at about 45 deg. toward the excavation. In blasting directly beneath the culverts two lifts, with light charges of dynamite, were employed, to avoid damage to the structures. Very close work was required of the pull shovel at these culverts, as there was only about 6 in. clearance between it and the arch, and the shovel was obliged to back out of the culverts to dump each shovelful of rock. Six inches of concrete was poured over the top of the pipe after laying, for some distance on each side of the tracks.

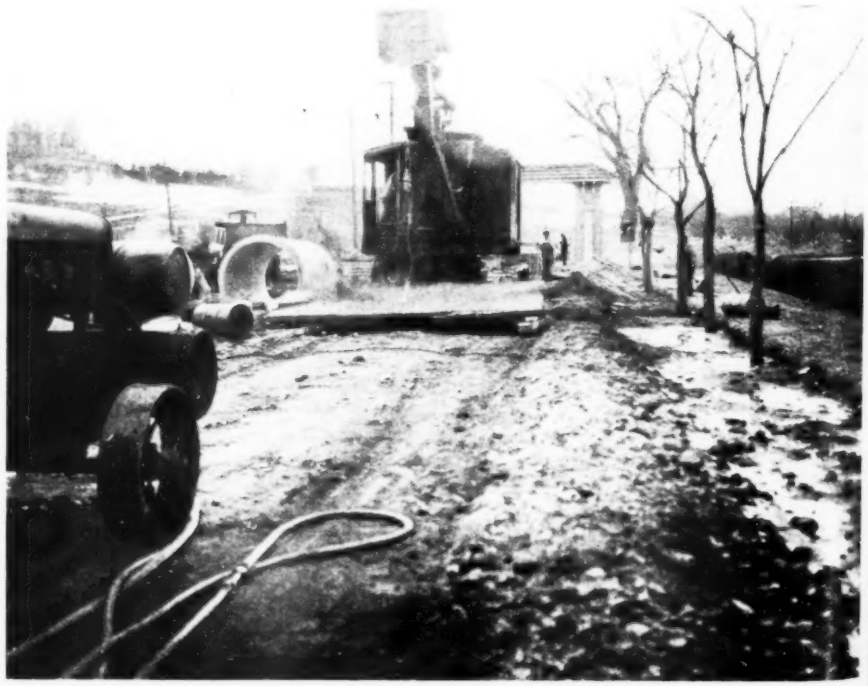
In the latter stages of construction unusually severe weather prevailed for weeks, although only one day's time was lost by the crews. For a time the surface of the ground was thawed ahead of the machines by covering with arched sections of heavy sheet metal and introducing flames from a blow torch at one end. Finally, however, the freeze became so deep that blasting was resorted to in breaking through the last mile of ditch. Three rows of holes, 2½ ft. deep and 3 ft. apart each way, were drilled. These were loaded with 1½ sticks of 40 per cent gelatin dynamite and three holes at a time were fired by the shovel operator, using electric wiring from the holes to the machine. Several rounds were fired in this way, the shovel being used to place a 6x12-ft. wooden mat over the shots as the firing progressed, and the shovel then returned to removing the loose dirt.

Wherever rock was encountered the pipe was laid on a 2-in. cushion of screened sand, to protect it from sharp edges of projecting stones. As much as 300 ft. of pipe per day was laid by one crew in the better going. A special plant was erected near the job, by the Lock Joint Pipe Co., the contractors, for manufacturing the pipe. Quick-sand occasioned some trouble at the crossing of Cherry Creek, but the use of the steel cofferdam with two 5-in. pumps overcame the difficulty.

D. D. Gross is chief engineer of the Denver, Colo., Water Department and H. R. Oliver was engineer in charge of the pipe line construction. W. W. Trickey was in charge of both manufacturing and installation for the Lock Joint Pipe Co.

Meeting of Arizona Public Health Association.—The third annual meeting of the Arizona Public Health Association will be held at the Adams Hotel, Phoenix, Ariz., on April 22 and 23, under the auspices of the State Board of Health. Health officers, city engineers, water works and sewage plant operators, dairy inspectors, public health nurses, and all others actively interested in community health and sanitation are cordially invited to attend this meeting. The committee is arranging an interesting program with special sessions for health officers, dairy inspectors, and water and sewage plant operators. Jane H. Rider, Box 167, University Station, Tucson, Ariz., is secretary.

Suggestions for Improving Public Service.—City Manager Sherrill of Cincinnati enclosed with each water bill recently mailed to citizens a postcard asking for suggestions as to how to better the public service. Several thousands of them were returned with helpful replies.



Firing a Round in Frozen Ground Ahead of the Shovel

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor

Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Planning Ahead for Plant Development

Having been much interested, during the past 15 years in:

(1) Improving the general fund of knowledge with regard to the subject of sewage disposal;

(2) Improving the status of the sewage plant operator;

(3) Training the operator up to the improved status:

The writer once more harks back to the matter of records of operation with the thought that such records may well be the basis of a program for future plant development; a program the economies of which will more than repay the municipality for all salary paid to a trained and efficient operator.

Our general fund of knowledge of the subject of sewage disposal has now progressed to the point where the designer of a sewage works can not feel that he has fully discharged his duty to the municipality by merely providing excessive capacities in the various units based on a predicted population 15 or 20 years hence.

In the first place, with the swiftly changing conditions of our American life, the development of new industries and the diversion of old industries to new fields (geographically) in search of better labor conditions, or to be nearer to sources of power or raw material, such predictions are seldom reliable.

Either we overbuild a plant up to which the community may never grow or due to underestimation we locate the disposal works at a point which long before its capacity is reached becomes untenable due to the encroachment of population upon it.

I recall a statement made many years ago by a railroad executive that, concrete was not a suitable construction material for round houses because it is too durable. The thought was, of course, that the march of progress frequently called for the destruction of such round houses and that the cost of demolition was excessive. Unfortunately, conditions under which sewage disposal works are built, and used, call for rugged design and construction although the life of the plant in any progressive part of the country is decidedly limited.

Aside from the difficulty of predicting probable growth of connected population and development of areas adjacent to disposal plant sites there is the problem of whether or not the present available methods of disposal and purification will either meet the demand or prove to be economical 15 or 20 years hence. Yet, on the other hand, there is the immediate necessity of providing sewage treatment in order to clear up our streams to the best of our ability and in the light of our present knowledge.

The custom of designing sewage treatment plants on the basis of a predicted population from 15 to 40 years hence is a natural outcome of good engineering practice in the design of other public works. Then, in addition to this consideration, there is the feeling that it is comparatively easier to secure a large sum of money for a sort of monumental work with the promise that such expenditures will not have to be repeated within an ordinary lifetime than it is to secure repeated smaller sums to build enlargements. Also many engineers feel that by providing excessive capacities based on a time quite distant, they can rest assured that at least immediate results will prove satisfactory with appropriate credit to themselves.

Here, again, sewage proves itself to be somewhat of an exception to accepted ideas of dealing with public works and the very excess capacities provided as a margin of safety may prove to be a boomerang by becoming odor producers.

From the economical point of view the designing of sewage plants for the distant future results in the tying up of municipal funds over a very long period of time in structures, some of which, for reasons already pointed out, may never become useful and will simply clutter up the disposal plant site. It is also true that a comparatively few persons have carried the burden of taxes to pay principal and interest over the years for the benefit of the far greater number who may or may not make use of the facilities at the end of such period. Though, theoretically, this sacrifice of the few will have been counterbalanced by the increased value of the properties owned by them, the writer believes that in practice the loss is actual.

Certainly, if, as is often the case, the adopted system becomes obsolete or the site becomes untenable, before the demands reach the constructed capacity the economic loss is tremendous.

From the operating point of view flexibility is a prime requirement, which is best met by a multiplicity of small units as compared with single large units. Such small units may also be capable of use for one of two or several purposes, as occasion may demand.

By the use of such small units designed for a reasonable immediate future demand, the capital investment is kept down and the plant may be expanded along the most useful lines as operating experience may dictate to be necessary to meet possible changing industrial demands, etc.

In building the plant gradually to meet the demands as they arise instead of building the plant in bulk to meet hypothetical future demands we not only eliminate much loss in interest but also much loss by deterioration which is very high in a sewage disposal works and especially so in idle parts of such works.

While it most certainly seems foolish to pay interest charges on structures which will not be used for many years and which during those years may become useless due to deterioration, changing conditions, or obsolescence, there is just as certainly much food for thought in the statement that it is easier to secure funds for the whole works at one time than to keep coming back for small sums. Moreover, the securing of funds for additions in the future years is highly problematical under present systems of financing in which the sewer department has to compete with all the other departments, many of which are much more popular, for a share of the annual municipal budget.

Fortunately, we are rapidly passing out of that era in which engineers assumed to design foolproof plants which could be built, started and forgotten. In fact through the agency of various organizations, some connected with matters of sanitation and some with sporting or merely ethereal interests

we have become educated up to a point where the sewage plant is no longer among things best forgotten.

It now becomes necessary to carry this matter of education forward to the realm of sane financing. The sewer rental laws and direct sewer assessment laws of Ohio and several other states make it possible in those localities to plan ahead for a comprehensive development program to meet actual conditions as we approach them, and to do this with confidence that funds will be available when required.

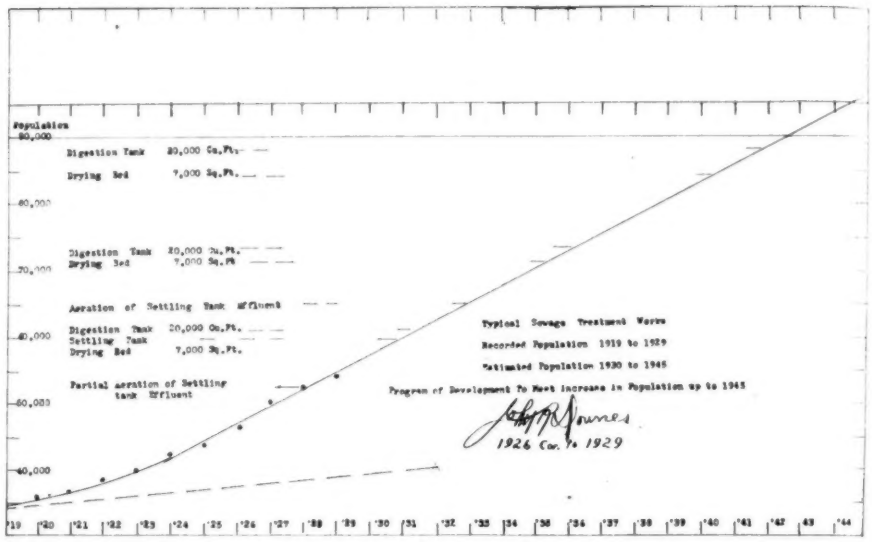
State health authorities would not be justified in approving plans for such deferred development except when assured and satisfied that an adequate financing program had been worked out and put into operation on an irrevocable basis which would preclude diversion of the funds.

The nature of the problem in sewage treatment and particularly this matter of financing, demand the continued sympathetic interest of a stable board of directors, whereas, the usual practice is to put the direction of sewer affairs into the hands of a councilmanic committee the personnel of which is constantly changing. The writer's experience has indicated very clearly the superior working conditions which will obtain under a more or less permanent commission which retains office long enough to become really familiar with and interested in the subject. It would seem proper that state health authorities in approving plans for deferred development should take into consideration the form of organization under which the plan would be carried out.

Coming, now, back to the matter of the operator and his records it is necessary that these records shall show correctly the number of house connections, the flow of sewage, the weight and volume of suspended solids in the raw sewage and in tank effluents, quantities and condition of sludge handled and the relative degree of oxidation of the effluent of oxidizing devices, also records of condition of the sewage as it reaches the plant with regard to its freshness.

From such records we may establish a basis for design of additions to the plant to meet the demands of the immediate future and may predict the financial demands to cover a development program for a period of years to follow. If population growth becomes retarded or accelerated, or if new industries impose new demands the program is sufficiently flexible to meet the changed conditions without any actual monetary loss.

The accompanying graph shows at a glance the proposed building program to meet the normal demands at a given


Population
80,000
60,000
40,000
Digestion Tank 20,000 Cu.Ft.
Drying Bed 7,000 Sq.Ft.
Digestion Tank 20,000 Cu.Ft.
Drying Bed 7,000 Sq.Ft.
Aeration of Settling Tank Effluent
Digestion Tank 20,000 Cu.Ft.
Settling Tank
Drying Bed 7,000 Sq.Ft.
Partial aeration of Settling tank Effluent
Typical Sewage Treatment Works
Recorded Population 1919 to 1929
Estimated Population 1930 to 1945
Program of Development To Meet Increase in Population up to 1945
1926 Cor. to 1929
'19 '20 '21 '22 '23 '24 '25 '26 '27 '28 '29 '30 '31 '32 '33 '34 '35 '36 '37 '38 '39 '40 '41 '42 '43 '44

Program of Development of a Typical Sewage Treatment Works to Meet Increase in Population Up to 1945

typical plant provided that the controlling conditions remain in line with those prevalent today. How far this prediction may be from the facts which may develop in the future is indicated by the lower dash line which shows the prediction for the population of the same area projected in 1912 on the basis of developments during the previous 15 years both in this and several other corresponding areas.

The particular plant for which the graph was made consists of: Mechanical screens, sedimentation tanks, separate digestion tanks, trickling filters and humus tanks. The connected population was approaching 50,000 and the trickling filters were approaching their capacity. As a result of previous experimental work partial aeration of the settling tank effluent was introduced in 1927-28 with decided beneficial effect of the trickling filters. Additional facilities for aeration will be required, as shown, in about 1932 though the exact requirements have not been worked out.

For purposes of comparison let us assume some arbitrary unit costs and examine the financial possibilities over the 15-year period 1927 to 1942.

In the table and calculation it was assumed that if the enlargements had been built in 1927 the cost would have been amortized over the succeeding 15 years and that under the deferred construction program, a sum equal to the annual payments on principal would be collected and added to the construction fund.

In addition to this economy it may be said that there would be an additional saving of 50 per cent in this case due to the definite information available from the records of the operator which make it possible to design to accurate needs rather than to some arbitrary rule of thumb.

Unfortunately there are few places at the present time in which such a plan could be carried out under existing laws and conditions. However, let us put every plant in charge of an operator capable and equipped to secure such data; and let every operator keep this goal in mind.

Comparison of Costs of Building Additions to an Existing Sewage Treatment Works to Cover the Requirements of the Next 15 Years as Indicated by Operating Data Over the Past Ten Years

Comparison Between Cost of Complete Equipment Built in 1927; and Costs When Different Small Units Are to Be Built as Required

Year	Payments Principal	Payments Interest	Costs Items	Costs Cumulative	Income Accumulated	Difference	5% Interest
27	7,733	5,805	1,000	1,000	7,733	.....	.....
28	7,733	5,418	.....	.....	15,466	.....	.....
29	7,733	5,031	.....	.....	23,199	.....	.....
30	7,733	4,644	27,000	28,000	30,932	.....	.....
31	7,733	4,257	9,000	37,000	38,665	.....	.....
32	7,733	3,870	.....	.....	46,398	.....	.....
33	7,733	3,483	25,000	62,000	54,131	7,869	393.45
34	7,733	2,856	.....	.....	61,864	136	6.80
35	7,733	2,709	18,000	80,000	69,597	10,403	520.15
36	7,733	2,322	9,000	89,000	77,330	11,670	583.50
37	7,733	1,935	.....	.....	85,063	3,937	196.85
38	7,733	1,548	.....	.....	92,796	.....	.....
39	7,733	1,161	.....	.....	100,529	.....	.....
40	7,733	774	18,000	107,000	108,262	.....	.....
41	7,733	387	.....	.....	115,995	.....	.....
42	.....	.....	9,000	116,000	.....	.....	.....
	$115,995	46,199	116,000	.....	115,995	.....	$1,700.75

Interest saved $46,199.00
Plus interest credit 2,838.55
Total saving by deferred building.. $49,037.55

Interest credits @ 5% $4,539.30
years when fund ahead
Net interest credit 2,838.55

The Water Works Manager's Job

An Interesting Outline of the Responsibilities and Principal Duties of the Manager of a Water Company

By W. C. HAWLEY

Chief Engineer and General Superintendent, Pennsylvania Water Co., Wilkinsburg, Pa.

THERE is no person in a community who renders to that community a more important service than does the manager of the local water utility. On him rests the responsibility, to a large extent, for the comfort, health and safety of the community. Of course he serves under a board of water commissioners or a board of directors, but the responsibility rests directly on his shoulders. If you doubt that statement spend an hour or two in his office some day when the force or supply main has burst and the town or a part of it is without water. Or drop in some day an hour or two after the man has gone out to shut water off from those who have not paid their water bills. Go with him some winter night when a big fire is in progress and the demand for water for fire protection approaches the capacity of the water works system. These experiences will give you some idea of the load he carries on his shoulders. He may spend only eight or nine hours per day in his office, but the responsibility is his, day and night, and seven days in the week. He may be called out of bed any time of night by the ringing of the 'phone to learn that the main on Broadway has "busted" or that there is a big fire on Second Street. When the 'phone rings at 2 a. m. and a voice asks, "Is this Dr. Jones?" he replies with a smile, "You have the wrong number" and when the voice says "I am sorry," he answers cheerily, "Don't mention it." And that's because he is so glad that it wasn't the engineer to tell him that No. 1 pump has a cracked cylinder or the night man at the office to say that an automobile has knocked over a fire hydrant and water has flooded various cellars.

Since our association is made up of water companies this paper will not consider the managers of municipally-owned water plants.

Three Major Responsibilities.—The manager of a water company has three major responsibilities:

To the company's stockholders, represented by their officers and board of directors.

To the public, represented by individual consumers, the municipal authorities and the public service commission, and

To the employes of the water company.

The question at once arises, "To which of these groups is he bound to give preference in service and loyalty?" In the old days this question would have been answered that his duty and loyalty were first to the company and its stockholders. I believe, however, that with our present ideas of public service the answer would be that the company, the public and the employes have a mutuality of interest, but that service to the public comes first, but it can be given only by building up an efficient organization of loyal employes, inspired by the idea of service and that the interests of the company are best served when the plant and the employes are giving to the public such good and satisfactory service as it has the right to expect.

Organization of the Employes.—The manager's first task, therefore, is to build up an organization of employes whose effiicency, enthusiasm and loyalty will result in such good service to the public that it will insure to the company and its stockholders the good will of and kindly relations with the public and a reasonable return. He must choose as members of the organization those who understand or at least those who can be taught and will try to understand their respective tasks and to perform their duties with credit to themselves and to the company. Special care must be exercised in the choice of those employes who come in contact with the public,—the clerks, meter readers, inspectors and particularly those who use the telephones. "Put a smile in your voice" is a good rule for a telephone company and it is just as good for a water company. A manager should not only insist on absolute courtesy in meeting the public,—he should employ only those who are naturally courteous. A cloak of assumed courtesy is too sure to be thrown off upon provocation and there is plenty of provocation in dealing with the public.

One of the fundamental problems of the manager is the creation and maintenance of an esprit de corps in his organization which insures absolute loyalty to the company and harmony among the employes. Water works service is a difficult service. It must be maintained 24 hours per day and seven days per week. Accidents, breaks, etc., may happen any time of day or night. Repairs must be made under all sorts of weather conditions and every effort made to maintain service or to renew it at the earliest possible moment. How shall he inspire the loyalty and devotion necessary to carry on? A prominent speaker recently said that industry is rapidly discarding the use of the word "hands" as applied to its employes. This is probably true, except on the farm, and perhaps that is one of the difficulties with our agricultural industry. Employes are being treated more and more as human beings. More consideration is being given to the comfort, health and welfare of the employes and those dependent on them. The number of hours per day and the number of days per week are being reduced, wages and salaries increased, working conditions improved, provisions made for group and co-operative insurance, sick benefits or part time payment during sickness, as well as nursing or hospital service. Vacations with pay are rapidly coming into favor. Pensions are provided for employes who have given long and faithful service and for those who have been incapacitated during employment. By such methods, the cost of which a live, up-to-date board of directors should be glad to authorize, a spirit of hearty loyalty and self-sacrifice where necessary can be built up among a corps of employes that will be well worth all it costs and which, of course within reasonable limits, the company has a right to charge to operation and to expect its consumers to pay as part of the cost of good service.

Operating Problems.—A manager's operating problems are many and varied. It is impossible to say which is of the greatest importance. One duty that is ever present is that of keeping the plant equal to any reasonably foreseen demand that may be made upon it. In designing a water works plant liberal allowance is always made for growth of the district served. Careful study should be made of the changes in population in the past and estimates made of increases to be expected in the future. It is the manager's task as new demands are made to increase capacity and extend facilities as may be necessary. Plans must be made so that service can be maintained while certain units are down for repairs. Watch must be kept of the condition of existing units and as a unit approaches the end of its useful life a new one should be installed. He should not wait until the unit in service breaks down before providing for its replacement.

Extensions to the distribution system are among the most difficult and puzzling problems which the manager encounters. This matter has been discussed at previous conventions and

there is little to be added at this time. Our Public Service Commission has laid down no rule which can be followed but it has, in recent years, handed down fewer decisions which appear to the water works man to be unfair than it did in the early days of the commission. In the light of experience since the previous discussion of this subject I would call attention to the necessity for considering not only the investment in pipe extensions, service lines and meters necessary to reach properties demanding service, but also something to represent investment in general plant necessary to serve. In many cases where extensions have been made the revenue will not be sufficient for years to come to carry more than the investment in the extension alone and in some cases not that.

Accounting.—A manager should keep in touch with the accounting of his company. Years ago when the classification of accounts for water companies was given us by the Public Service Commission there were many who thought that it was unnecessarily elaborate and involved. To some of the smaller companies it may be a burden but I think in general, the larger companies find it helpful and well worth all the trouble and expense which it causes.

In the classification prepared by the Public Service Commission the distribution of expenses is made by a system of numbers. It is easy to make mistakes in such a system. The memory will not always choose the right number and figures will be inverted. It is believed that a voucher distribution system using letters with only a few numbers, and those numbers having definite meanings, is less liable to result in error than a system of numbers. For instance, the letter C can be taken to mean "construction" or "additions to plant account"; O—"operating"; E —"expense"; M—"maintenance," etc. Numbers would be used to indicate units or structures known by number. For instance, "CR2" would mean an item chargeable to "construction of reservoir No. 2" and "MP3" would mean "maintenance of pump No. 3." This means that the particular item is associated with the structure or the unit to which it is chargeable.

Rules and Rate Schedules.—There is nothing more important to a water company than that its rules shall be reasonable, comprehensive and so well stated as to be readily understandable to people of ordinary intelligence. The same applies to its rate schedule. Unless it has such rules, one of the first jobs of the manager should be the preparation of new rules to be properly adopted, filed and posted. Many of the company members of our association have adopted new rules within recent years. Those that have not should give the matter serious consideration.

Since beginning the preparation of this paper there has been received the decision of the Public Service Commission in the case of the Borough of Snow Shoe, et al. vs. the Snow Shoe Water Co., decided by the Public Service Commission Dec. 21, 1928. In this decision will be found a rate schedule and a set of rules which the water company in that case was ordered to file, post and publish, which will be of great assistance to any water company revising its rules and rates. The rules in particular have evidently been prepared with great care and thought and in many respects are an improvement over the rules now in force by most of the water companies of the state. There are a very few things in them which the experienced water works operator will realize as at least doubtful but they will serve as an excellent model to any water company that is rewriting or amending its present rules.

Enforcement of Rules.—Then follows the reasonable enforcement of the rules. No consumer should be told that he "has to" or "must" do a thing because the rule says so. If the rule is a reasonable rule the consumer is entitled to the explanation and with an intelligent consumer this is generally sufficient and not only that, he goes away with the impression that the company's rules are not arbitrary but that there is a reason for them, and if he has been courteously treated he is likely to spread the good news. Every effort should be made to avoid discrimination or preferential treatment of consumers. It is sometimes difficult to refuse a request of a prominent citizen or a politician or a personal friend but if the manager refuses a request made by Smith and Smith then shows that he has done the same thing for Jones, the manager finds himself in an embarassing position. If that sort of thing continues his rules will be of little use to him.

Employes should be familiar with the rules and should understand the reason for every rule and so far as possible, its application, so that they can explain the rules and their enforcement to those who make inquiry or who may object to some enforcement of a rule or rules. Nothing makes a consumer more angry than to have some clerk or other employe who evidently can give no reasonable explanation of some method of doing business or of some rule, act in an arbitrary manner or put up a bluff. We have enough trouble without creating more by such conduct on the part of our employes but it seems hard for some of them to realize when they do not know the answer to a question and harder still to admit it and call on some other employe who does know and can make a reasonable presentation of the matter to the customer. Such an employe should either be discharged or put in a position where he will not have to meet the public.

Relations of Company to City Served.—The relations of a water company to the municipality which it serves and to the municipal officers are very important. The attitude of the municipal authorities generally reflects the attitude of the community toward the water company. If the service is good, the treatment of patrons courteous and the rates reasonable, the people of the community are generally friendly. If not, the dislike of the people for the water company will be reflected in the attitude of council and other officers. There are other factors such as the attitude of the local paper or papers and some times there are politicians who think they can make political capital by attacking any public utility. In recent years where there have been differences, an effective way of settling them has been to arrange for a meeting where the differences can be frankly discussed and the water company can lay its cards on the table and explain its position. Such a method is at least worth a trial, but the manager must be very sure of the reasonableness of his position and be able to present the reasons for it in a way that will be appreciated by the representatives of the municipality.

The Pavement Problem.—A problem which is causing water works managers much trouble at the present time is the laying of pavements, especially concrete or with concrete foundations. Naturally there are objections to opening such a pavement for laying service lines, etc., and yet it is sometimes necessary. It is up to the manager when a pavement must be opened, to see that it is replaced in such a manner that the pavement is not damaged in any way. It is impossible to foretell where a service line will be needed or what size will be needed and the Public Service Commission has refused to compel a water company to install service lines before paving. Service lines and mains will sometimes leak and hence it is necessary to cut through pavements, but the municipality is right in its insistence that as few openings as possible shall be made and that the ditches shall be back-filled and the pavement replaced properly.

The more personal friends the manager has the better will be the standing of the water company among the people that it is serving. He should take a part in all civic activities such as the chamber of commerce or board of trade, business men's association, etc., and in one of the service clubs. His activities in such matters will make friends for the water company.

Importance of Records.—He should keep records showing the increase or decrease in plant account, income and expenses, taps—active and non-active, meters, pipe lines, valves, fire hydrants, etc. Such records can best be used for comparison if plotted on a cross section paper. I strongly suspect that if such records were kept they would

show that in most cases in recent years plant account has been increasing at a rate much exceeding the rate of increase of net revenue. This will be especially true of those plants where it has been necessary to increase investment in general plant such as pumping machinery, reservoirs, supply mains, etc., for there is no corresponding increase in consumers.

Meter Readings.—Special attention is called to the matter of meter reading and the information to be gotten and recorded by the meter readers. The meter reader should be a young man of some education, absolutely courteous, who takes an interest in his job. He should be carefully instructed in his duties and his work checked closely enough to know that he is carrying out his instructions. He should not only read the meter carefully and check to make sure that he is right, but he should get such other information as to leaks or other reasons for unusually large registration, etc., as he can, and that information should be recorded on the meter sheet. The meter book when returned to the office should be gone through carefully and any indication of a meter being out of order and not registering or of excessive consumption should be recorded and the man who is sent out to get the "aways" should check the condition of reading of the meters listed, and get any other pertinent information. By such methods mistakes are avoided and the information obtained is worth all it costs and more. Frequently when a consumer objects to the payment of a large bill, declaring that there has been no leak or other reason for unusually large registration, a reference to the meter book which shows that there was a leak in a certain fixture or that gives other definite information will end the argument. On each meter sheet there should be a record of the date of the last test of the meter and the reading at the time of that test. From these records it is readily seen when the meter should be tested in compliance with the rule of the Public Service Commission.

Valve Records.—Records should be kept of the operation of valves, each operation being reported on a report form giving date, time, name of person operating and reason. There should be regular tests of both valves and fire hydrants to see that they are in proper operating condition. This is the only way that one can be sure that the valves are all open or that the fire hydrants are in proper condition to operate. It is especially necessary as to fire hydrants in these days of automobiles.

On every water works plant of any size there should be installed a pressure recording gauge and, on large plants, two or more as may be necessary. The records of such a gauge will be of great value as indicating the adequacy or inadequacy of distribution system or supply main or in case of fire and a charge of low pressure they tell just what happened. They will show when a break occurred and how long it took to close the valves and restore normal service.

A water company is able to economize in the purchase of many of the supplies entering into its plant to a greater extent than is possible to a municipally-owned water works system. It can standardize on such items as valves, fire hydrants, service line materials and meters. In this way it avoids carrying a multiplicity of repair parts and by choosing the best, can save in costs of maintenance. There is no reason for installing half a dozen different makes of valves for instance and having to carry repair parts for all these different makes. There is no reason for having fifteen or twenty different kinds of meters. A first-class meter, or at most three or four, can be chosen as the result of experience and adopted as standard. A meter so chosen can be purchased as cheaply or even at a lower price than could be obtained for a good meter in competition and the saving in cost of repair parts to be carried and in the cost of storing them and keeping account of them is well worth while.

Adjusting Bills.—One of the water works manager's most trying problems is that of adjusting bills for consumers when the meter has been out of order or stopped registering during all or a part of the period for which the bill is made. Anyone who has had experience knows that there is no hard and fast rule that can be applied. The rules approved for the Snow Shoe Water Co. previously mentioned provide: "The quantity of water consumed shall be estimated by the average registration of the meter on previous corresponding periods." Such a rule is about a one to five shot. That is, it may apply in one case out of five. If the same number of people are occupying the property, if there has been no unusual waste or leakage and conditions generally are the same, it is an excellent method, but any change in the number of persons supplied, the difference between a wet and a dry season where lawns are sprinkled, etc., will render it of little value. Registration for a period of reasonable length immediately before or immediately after the time when the meter was out of order, or possibly an average of the two, will in many cases give a fairer result. One of the best methods is to plot the registration of the meter on cross section paper for a period of two or three years. This method will give information which is not readily observed from a study of the meter sheet and sometimes the information is surprising. In any case it is a matter of good judgment and the honest effort to arrive at a result that is fair to both consumer and water company. It must not be arbitrary but the method should be such that the reasonable consumer will be satisfied with it.

As has been said previously, the manager in giving good service to the public is best serving the stockholders and officers of the company which employs him. There are, of course, his duties in the preparation of reports, estimates, statements by which the directors are kept advised of the condition of the company and its activities and the good manager will consult his board of directors and ask for advice and aid in carrying out his work. He should receive the support, co-operation and assistance of the directors in all he undertakes.

This paper has touched on some of the principal duties of the water works manager, but there are many other minor duties that there is no time to discuss. He has many perplexing problems and some that are aggravating, but I know of no business that has the infinite variety of interesting questions and problems arising constantly. Mixed with this, too, there is a spice of humor, for many funny things occur in a water works office. It is this variety and the satisfaction of giving useful service that makes the water works manager's job so interesting and worth while. Under his direction millions of gallons of water are supplied to meet the vital needs of the community. Surely he should share in the blessings promised to him who gives a cup of cold water.

Acknowledgment.—The foregoing is an abstract of a paper presented at the last annual meeting of the Pennsylvania Water Works Association.

State and Municipal Bond Election Results During February

Bond authorizations reported by 76 municipalities during February aggregated $17,772,500, the largest total for February of any year since 1926, according to "The Daily Bond Buyer" of New York. The figure for February of last year was $13,309,998; for February, 1928, $8,204,600, and for January, 1927, $15,326,500.

A few of the larger authorizations last month were $6,230,000, Tulsa, Okla.; $4,000,000, Birmingham, Ala.; $850,000, High Point, N. C., school district, and $690,000, Clayton County, Iowa.

Proposed issues by 33 municipalities in 17 states, aggregating $7,861,993, were rejected by the voters as compared with $5,122,000 in February, 1929; $6,951,500 in 1928, and $4,963,500 in 1926. Among the larger projects defeated were $3,453,000, Phoenix, Ariz.; $500,000, Tulsa County, Oklahoma, and $492,000, Lawrence County, New Jersey, school district.

How Ancient History Throws Light on Weather Cycles

By HALBERT P. GILLETTE

VIGOROUS efforts are being made to determine the nature and length of weather cycles, and every scrap of evidence is being carefully reviewed. The varying thicknesses of the annual rings of trees for nearly 32 centuries, and the annual clay laminae, or "varves," deposited in ancient glacial lakes back for about 160 centuries are under rigorous analysis. Even ancient history has been summoned to testify as to weather, not merely through its occasional mentions of extraordinary storms, floods, or droughts, but through its more frequent accounts of great wars, migrations and colonizations.

It has gradually dawned upon a few researchers in the realm of meteorology that many, perhaps most great wars of early days were the direct result of severe climatic stress, and not the result of innate greed, animosity or bloodthirstiness. In Brooks' "Climate Through the Ages," several chapters are devoted to a brief review of early migrations. He gives approximate dates of these "waves" in the hope that they will cast light on the problem of climatic cycles, as well as to indicate that climate has certainly varied greatly during the past 50 centuries.

Study of rainfall, floods, tree-growth, clay varves, aurora, sunspots, earthquakes and volcanic eruptions had convinced the writer that there is a cycle of 633 years that is to be found in all of these phenomena; and that there are very important subcycles of one-third of 633 years, or 211 years. A cycle of about 210 years in the maximum floods of the Nile had been previously pointed out by del Valle, based on his study of the flood records back to 641 A. D. The greatest floods of the Nile occur when American and European rainfall is at a minimum, so, bearing this fact in mind, the writer saw that the del Valle cycle of about 210 years fits almost perfectly with his own discovery of the 211-year subcycle above mentioned.

The next step in testing the existence of the 633-year cycle consisted in comparing its calculated peak or maximum dates with historical records of migrations and wars. A few examples of the results of this study will be given.

Weather records had pointed strongly toward 1323 A. D. as a maximum or peak date of this 633-year cycle; so 3 cycles prior thereto brings us to 1209 B. C., which was about the time that the "Bronze Age" people of the Hungarian plain and the Phrygians migrated in "waves." Brooks states that many of the "lake dwellings" in Europe were destroyed not long after 1300 B. C., due to a great rise in the lakes. He states that in 1180 B. C. the Elanites migrated, which is only 29 years after the weather cycle peak of 1209 B. C. The Hoskos peoples conquered Egypt about the year 1800 B. C., which is only 42 years after the previous weather cycle peak of 1842 B. C. The Kassiterite migrations occurred about 2450 B. C., which is only 25 years after the previous weather cycle peak of 2475 B. C.

Britannica says that the Cinmerians were expelled from Phrygia somewhat before 585 B. C. It is therefore noteworthy that one of the peaks of the 633-year weather cycle was in 576 B. C. The next weather cycle peak of this series was in 57 A. D., and about 50 A. D. the Jafnite migrations from Yemen occurred.

When it is remembered that the dates of some of these migrations are not precisely known, and that for about 25 years before and after one of the "peaks" of the 633-year weather cycle the weather is greatly disturbed, it is seen that the above mentioned migrations are in excellent accord with the dates of the maxima of the 633-year cycle.

The writer has found four long cycles that have a striking relationship, namely that each is about twice the length of the next shorter one. Their approximate lengths are 81, 162, 316 and 633 years. Evidence is accumulating that there is a cycle almost exactly 8 times the last one named above. The first two cycles of this series of four cycles are due to Uranus and Neptune, each cycle being slightly shorter than the orbital period of the planets. The reason for the difference between the orbital period of a planet and the weather cycle that it causes seems to be this: The planet has an upper magnetic field in its atmosphere (like the Heaviside shell of electrons 75 miles or more above the earth) and the poles of this magnetic field rotate clockwise very slowly around the axial poles of the planet, whereas the planet travels counter-clockwise, which therefore causes this magnetic axis to point most nearly sunward and earthward oftener than once every revolution of the planet around the sun. Upon such occasions many storms occur on both sun and earth; the solar storms being the "sunspots."

The winter of 1323 was the coldest on record, and if it was caused by a planet whose cycle is 633 years, then we can look for very severe weather about 1956. For a generation before and after 1323, weather was greatly disturbed. The effect of the planet that probably causes the 633-year cycle is perhaps to be seen in the very unusual weather that has been recently experienced in many regions.

A Jupiter weather cycle of 11.2 years and a Uranus subcycle ($\frac{1}{4} \times 81.1 = 20.3$ years) have had "peaks" recently, and they have apparently been reinforced by the approaching cycle "peak" that will reach its apex about 1956.

Earthquakes and volcanic eruptions are always more numerous and more violent at times of the great weather "peaks," presumably because the same magnetic forces that affect the electrons in the air coincidently affect the electrons in the earth's molten interior. We need not be surprised, therefore, to hear of an unusual number of crustal disturbances, increasing intermittently, for the next 26 years.

In the following table the dates of the maxima or "peaks" of 6 important weather cycles are given, also the average length of each cycle. Names have been assigned to the two invisible planets that cause the two long cycles.

Planet	Cycle, Years	Date of a "Peak"
Jupiter	11.2	July, 1928
Saturn	28.1	December, 1925
Uranus	81.1	August, 1889
Neptune	161.6	January, 1837
Apollo	315.5	May, 1778
Janus	633	Winter of 1323

Each planet also causes weather subcycle peaks at intervals whose average length is one-twelfth of its cycle length, the semicycle "peaks" being usually the most pronounced of the subcycle "peaks."

It is scarcely to be wondered that meteorologists have found it very difficult to make reliable long-range forecasts, when there are at least 10 main weather cycles due to 10 planets, besides many subcycles of the main cycles. Without knowledge of the cause of weather cycles, even though the existence of such phenomena was more than suspected, and with but vague discernment of the length of only a few of the scores of cycles, it is not surprising that many meteorologists have questioned whether man ever can unravel the snarl called weather.

Cross Reference.—For discussion of an allied article entitled "The Synchronism of Planet Orbital Periods and Sunspot Cycles Due to the Planets," see March, 1930, issue of *Engineering and Contracting*.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Filtration Engineer, Bureau of Engineering, Chicago, Ill.

Filter Bed Clogging

ONE of the problems that have baffled filter plant designers and operators from the very beginning of rapid sand filtration is the formation of clogged places in filter beds. These are areas of the sand bound together so firmly they are not broken up during washing. In the discussion of filter beds and cracks in filter beds, in the January and February, 1930, issues of Water Works and Sewerage, reference was made to temporary clogging in filter beds. This is clogging caused by coagulated matter penetrating into the beds, which is broken up and washed away each time the filter is washed.

In the present discussion we are considering clogging that is due to the sand being bound together so firmly it is not broken up by washing the filter. These clogged areas may vary in size from a few sand grains bound together to areas that extend from the gravel to the surface of the bed. The small clogged masses may be found distributed throughout the sand, but the larger ones rest on the gravel.

The size a particle has to be before it will settle to the bottom of the sand and will not be moved about by the washing varies with the specific gravity of the mass and the force of the wash water. So long as the clogged masses keep distributed throughout the sand bed they are of practically no significance in their effect on filtration, except that they may be breeding places for bacteria. It is when they form to such size as to settle to the bottom of the filter that they become of importance. No clogged area becomes of enormous size immediately, and very likely all large clogged areas have their start in clogged masess less than 1 in. in diameter.

The writer dicussed the formation of clogged areas in filter beds in 1924.* There have been no recent developments requiring a modification or change in what was presented at that time, but the subject is of such importance as to justify another and more thorough discussion; especially so as the data presented in 1924 did not impress the filtration profession to the extent that much improvement has been made. The leading filtration engineers are not now designing filter bed that remain any freer from clogging than the beds constructed years ago. The writer hopes that we are now near a solution of such troubles, but little has been done so far in filtration plants to prevent filter bed clogging. It requires an extended use of any device, or any change in operation to correctly judge its efficiency. The present article will be limited to discussing conditions that cause clogged areas to form, and a later article will deal more fully with means of preventing and breaking up such areas.

Fig. 1—Meshwork of Clogged Areas in Filter Bed

Filter plants throughout the country will be found varying all the way from beds that have no clogged areas to beds that become so badly clogged that fully one-half of the sand in the bed is bound together. Perhaps the design of the filter has some influence, but this is not the major factor. Two

Fig. 2—Clogged Places Diminishing in Size

*Baylis, John R. Sand-Bed Studies at Montebello Filters, Baltimore. Eng. News-Record. 92: 13, 516-22, March 27, 1924.

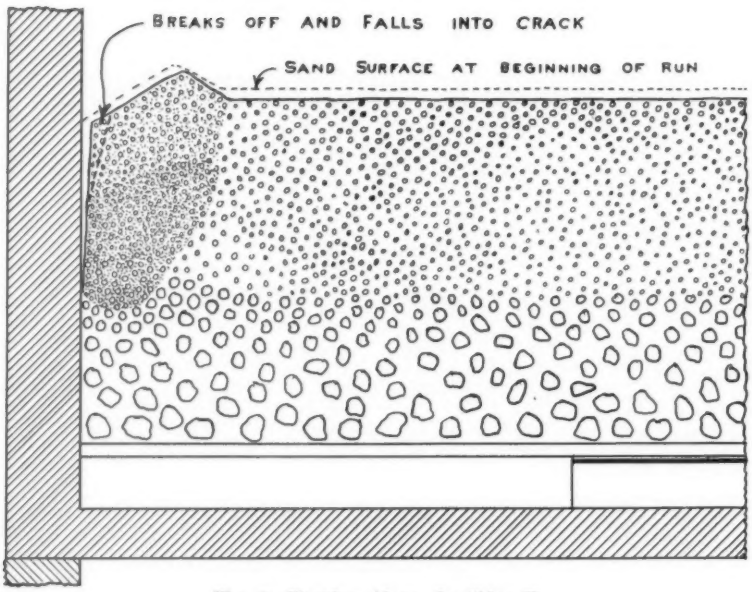


Fig. 3—Clogging Along the Sidewall

plants of the same design, with the same kind and size of sand in the filter beds, may vary greatly in their tendency to form clogged areas. The evidence is so strongly in favor of the character of the water being the major factor that this may be stated to be an established fact.

Cause of Clogging.—It is evident that the sand grains are held together by some adhesive substance. It also is evident that aluminum hydroxide or ferric hydroxide as ordinarily precipitated in coagulating water is not tough enough to furnish the adhesion necessary to bind the sand grains together unless there is some way in which much of the water could be squeezed out of the gelatinous precipitate. Even then these precipitates probably are not as adhesive as certain other materials. It is not believed that the binding material can be attributed to the coagulant alone, for if this was the case all filter beds would form clogged areas. It is likely that organic and possibly silicious jellies are more responsible than any other material. Some of the highly turbid waters may carry enough clay in suspension to be of aid in making a plastic precipitate; however, clogging is not confined to turbid waters. In fact it seems to be more pronounced where the water is not so turbid, though there are many exceptions to this statement.

Water that causes the formation of gelatinous coatings on the sand grains usually gives the most clogging trouble. This may be due partially to more adhesive material being present and partially to cracks in the bed. Sand with a gelatinous coating almost invariably settles during the run, causing cracks to open up along the sidewalls and frequently all over the surface. The cracks allow an accumulation of coagulated matter beneath the surface of the bed. When the wash water is first turned on, the sand begins to bulge in places, forcing the cracks together in other places. This may force together quite firmly the coagulated matter which has accumulated within the cracks and form clogged masses of sand and the tough material filtered out on the sides of the cracks. Such an assumption would be difficult to prove, but it seems probable. Cracks in filter beds are not necessarily forerunners of clogging, though they likely give considerable aid. When the clogged places begin to break up or diminish as the water gets colder in the late fall or winter, cracks in the surface of the filters may be more abundant than in the summer and early fall, when the tendency to clog is the greatest, so the cracks are not the main factor.

That there is a direct relation between the characteristics of the suspended matter in the water and the tendency to clog is evident from what takes place in many filtration plants. The writer has observed plants in which there will be serious clogging in the summer and fall months and practically no tendency to clog in the colder months. A bed in these plants in good condition at the beginning of winter usually remains in good condition until spring or summer. In fact most clogged places which form in the summer and fall will break up in the winter. The quickness with which clogged places will form when the tendency to clog is great is illustrated in Fig. 1. The filter was put in excellent condition by removing the sand and finer gravel, thoroughly washing, screening, and then returning the material to the filter. The procedure was to eject the sand from one bed to another with a Nichol's sand washing machine after the gravel had been put into good condition. The sand after washing was free from clogged masses and perfectly clean, with the exception of a very tough and hard coating composed largely of organic matter, silica, aluminum hydroxide, and manganese dioxide. This coating was so hard there was no tendency for the sand grains to adhere when pressed together.

When the bed was put back into service Nov. 7 it was in perfect condition. To be sure that biological growths on the sand grains themselves would not be a contributing factor, chlorine was added to the water prior to filtration to the extent that there was an excess of at least 0.3 parts per million residual after filtration. By Nov. 25, 18 days afterwards, there were many clogged places, as is shown by Fig. 1. All filters in the plant showed this same tendency to clog. About the first of December all the filters began to get in better shape, regardless of whether the water was or was not prechlorinated. Figure 2, taken Dec. 17, at the same point in the bed as Fig. 1, shows considerable clearing of the clogging.

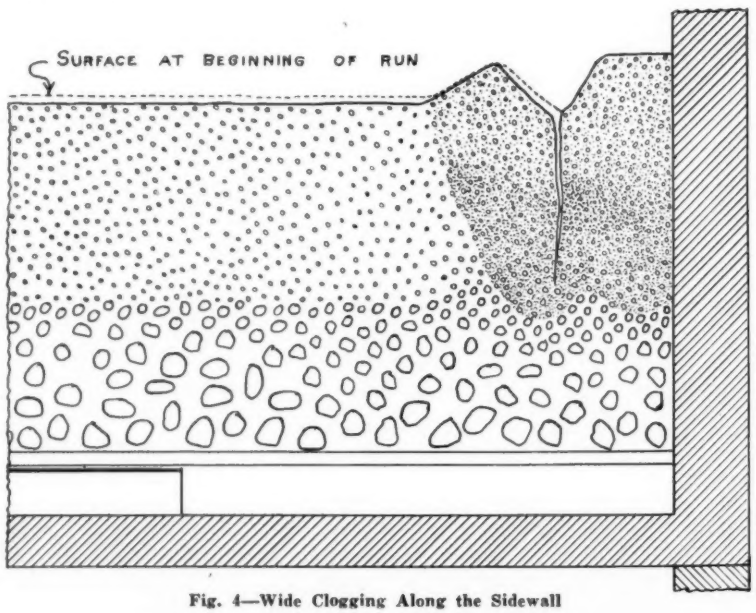


Fig. 4—Wide Clogging Along the Sidewall

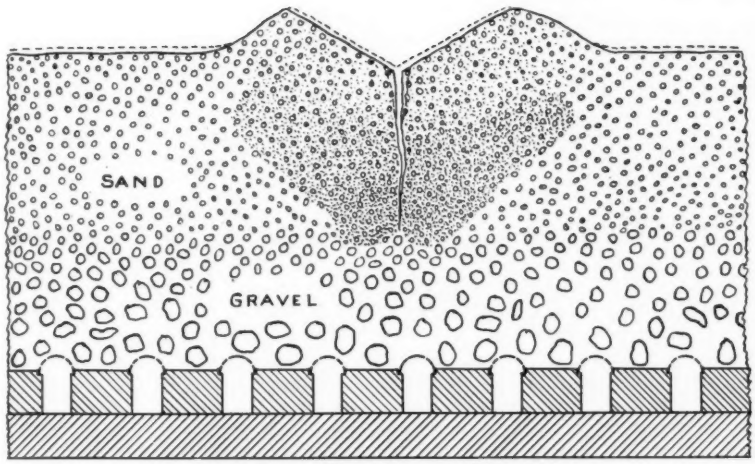


Fig. 5—Large Clogged Area in Filter Bed

By the first of January there was scarcely a clogged place that could be observed not only in this bed but in the others as well. All the beds remained in good condition, with the exception of a few clogged places along the sidewalls, until June or July, when the clogged places again appeared. This same procedure repeated itself year after year, but with the clogging not so extensive some of the years. Here we have water from the same source varying greatly in its tendency to cause clogging. These remarks should not be construed as meaning that the design, treatment of the water, and method of washing the filters have no influence. They do, but the major factor is the characteristics of the suspended matter, especially where standard practice has been followed in the design and in the operation of the filters.

The first visible evidence of clogging in a filter bed is slightly raised places in the sand surface, though it is evident that the clogged areas must be of considerable size to produce the raised places in the filter surface shown in Fig. 1 and 2. If a stone 6 in. in diameter was placed on top of the gravel in a sand bed 2 ft. deep there likely would be no visible evidence of the stone being present, but a stone 12 in. in diameter very likely would cause some unevenness of the surface. This is not to imply that it takes a clogged area 12 in. in diameter to become noticeable. The main factor is the nearness with which the clogged area extends to the surface. All clogged areas of any size must rest on the gravel, and unless they build up to considerable height there may be no evidence on the surface of their presence.

Clogging Along the Sidewalls.—There are very few filtration plants in which the filter beds do not form clogged places along the sidewalls, occasionally if not all the time. In many plants the sidewall clogging is all the clogging that takes place. Evidently this is the part of the filter having the greatest tendency to clog. Practically all filter beds are pushed away from the sidewalls as the loss of head increases. The cracks vary from ones that are almost negligible to cracks that may be 1½ in. wide at the top of the bed. This forms a filtering surface along the side of the bed where the crack has formed that acts as a filtering surface the same as the top surface of the bed. The accumulation of coagulated matter on this surface occurs to nearly the extent it does on the top surface. When the wash water is first turned on the sand is forced against the sidewall, pressing the coagulated matter firmly between the sand and the sidewall. If the coagulated matter contains adhesive matter it tends to stick both to the sidewall and the sand in direct contact with it. It adheres to the sidewall so firmly it is not removed by the washing. Also some of the sand remains firmly bound into the adhesive mass. When the crack opens up again on the next filter run the clogged masses, which at first are quite thin, may continue to adhere to the sidewall or they may pull away with the sand. Additional coagulated matter collects in the crack and the process is repeated. Each time the crack opens on the run and coagulated matter is deposited in it, additional material is added to the clogged masses.

Eventually the clogged masses become so large they drop to the gravel layer during washing. An accumulation of these clogged masses start clogged areas on the gravel surface, and the areas become larger and larger as additional clogged masses fall on top of the ones which have already settled to the bottom of the sand. The washing tends to break up some of them, but if they are forming at a rate faster than they are being broken up, soon a large clogged area is formed. This is usually against the sidewall. Deflection of the wash water by the clogged areas has a tendency to deposit an increasing number of clogged masses on top of the clogged area, building it higher and probably a little wider. Eventually the clogged area reaches a height near the top of the sand. Some of these sidewall clogged places become quite wide, as shown by the sketches in Fig. 3 and 4. The condition shown by Fig. 3 occurs in many filtration plants, even though no clogged places may form in the center of the beds.

After the clogged areas reach nearly to the surface they usually widen in a manner probably not so well understood by many filter operators. It is believed that they do not widen to any material extent by adhesive matter adhering to the side of the clogged area that is towards the sand not clogged. The clogging tends to restrict the area of the bed, and if the wash water continues to be applied at the same rate the velocity is increased in proportion to the area clogged, increasing the tendency of the wash water to wash away the clogged places. Almost invariably there is shrinkage of the sand beds during the runs in filters that have clogged places and, as was stated in the February issue of Water Works and Sewerage, cracks form along the sidewalls where there is shrinkage. In nearly all instances the crack is at first between the clogged place and the sidewall. This is illus-

Fig. 6—Badly Clogged Filter Bed

trated in Fig. 3. Sometimes when the clogged area builds up very wide it becomes so large it is difficult for the wash water to tilt it and it becomes fixed. Then the crack opens between the clogged mass and the sand not

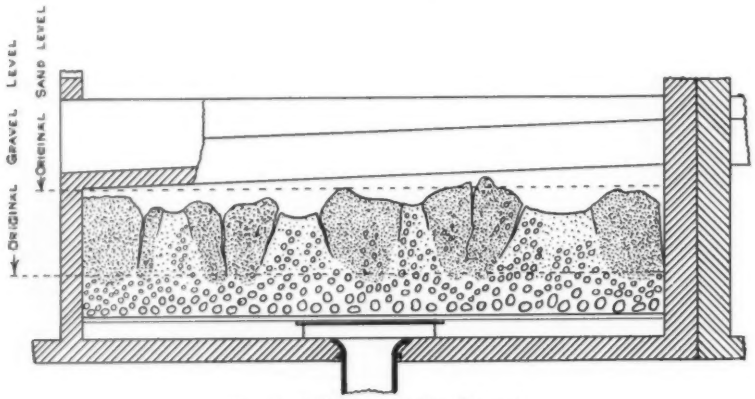


Fig. 7—Filter Bed Badly Clogged

clogged. Soon this builds up a clogged area by the side of old clogged area in the same manner as the clogged area was built up against the sidewall. This is shown in Fig. 4.

The writer will explain his interpretation of how clogged areas become wider. This is based on observation of many clogged places covering a period of several years. The clogged areas are held together so firmly they act as solids, except that a little water may gradually percolate through them. On each filter run the sidewalls crack open as the loss of head increases, tilting the clogged area. Each time the filter is washed the clogged area is tilted back against the sidewall. This compacts quite firmly any material getting into the lower part of the crack. So long as the filter is running there is enough side pressure to hold the sand together, but when it is cut off to be washed some of the sand near the top of the bed breaks loose and falls down into the crack. This is shown by the broken line in the upper left hand corner of the clogged area in Fig. 3. The sand dropping into the bottom part of the crack is mixed with coagulated material and the mixture is compacted quite firmly. It also is in a place where it is not disturbed by the wash water. If this material after compacting is ¼ in. in thickness, it is evident that the clogged area has been widened that much. There is the possibility that the clogged area is tilted the distance of the thickness of the compacted layer each time and that the process of widening is a gradual turning over of the clogged area.

It is believed to be more probable that the widening of the clogged area is by pushing the mass away in a nearly horizontal direction. When the wash water is turned on there is considerable force tending to lift the clogged places. With a washing rate of 15 gal. per square foot per minute the upward pressure is approximately 100 lb. per square foot for the average filter bed. This is not equal to the weight of the clogged area, but it probably is enough to so lessen the friction on the bottom as to allow it to be pushed away by the material being wedged between it and the wall near the bottom of the crack. Either tilting or being pushed away horizontally will explain the widening of the clogged areas. Perhaps they act in both ways in many instances. The significant fact is that the sidewall clogged areas do not build up on the side next to the sand which is not clogged, but on the side against the sidewall. Probably the only exception to this is the starting of a new clogged area against one that has grown so large it has become fixed and does not tilt on the filter runs. Then the widening is by building up between the two clogged areas.

Clogging in the Center of the Bed.—As previously stated, many filter beds do not form clogged places in the center of the bed; however, there are many that do. The center clogged places very likely have their origin somewhat similar to the places along the sidewalls, but they must depend on the clogged masses which form on or near the surface to accumulate and settle at points in quantities sufficient to start the clogged area. Why the clogged areas form in what may be termed a meshwork of areas is not definitely known. This formation is indicated very clearly in Fig. 1. The areas are not individual clogged places separated from each other, but they are joined together throughout the bed. It is true that the areas in Fig. 2 are separated from each other, but they are areas breaking up and diminishing in size. A number of photographs taken by the writer show the same characteristics as Fig. 1, except when the areas begin to break up in the winter months.

The writer is of the opinion that the washing causes this characteristic. If we examine a filter bed being washed when the water is coming off so clear the suspended sand may be observed, it will be found that the bed is a series of boils with the water and sand rushing upward in places and downward in other places. Very likely it is around these boils where the downward current strikes against the gravel that the small clogged masses are deposited and accumulate to the extent that they form clogged areas when the tendency to clog is great. The more highly a bed becomes clogged the more it gives characteristics of this phenomenon.

The center clogged places widen in a manner somewhat like those along the sidewalls. When the areas reach a height that they cause raised places in the surface, cracks form along one side of the clogged areas. Such cracks may be distinguished in Fig. 1 along the side of some of the narrower ridged places. One place is readily noticeable in the foreground near the center. The cracks act to widen the clogged areas in the same manner as the sidewall clogged areas are formed. In this case the clogged area already formed acts as the sidewall and another clogged area builds up on the opposite side of the crack. Figure 5 is sketch of a large center clogged place. It will be noted that the clogged places are split in two with a crack somewhere near the center. These characteristic clogged places with the crack near the center may be seen in the wider clogged places shown in Figs. 1 and 2. While

Fig. 8—Large Cracks Within Clogged Area

the clogged areas are diminishing in size in Fig. 2, they continue to build up from the center. They are being washed away on the outside, however, faster than they are being built up from the center. Material removed from the water by filtration and some of the sand fall into the bottom of the cracks when they open on the run the same as it does along the sidewall, especially when the filter is cut off to be washed. When the filter is washed this material is compacted by being wedged in the crack just as it is in the sidewall cracks. In this case it is mashed together between two clogged areas. The compacted material adds to the clogged mass and forces the clogged masses apart; that is, the clogged areas are built wider from the center, or from the crack wherever it happens to be.

Figures 6 and 7 show how badly a bed may become clogged. The photograph in Fig. 6 shows the sand excavated to the original gravel layer in one place, which is indicated by the X mark. The arrow points to gravel within a few inches of the surface. Over one-half of the area of the bed was clogged and some of the sand had been lost by being washed through the disturbed g r a v e l. A washing rate of approximately 15 gal. per square foot per minute had been maintained notwithstanding such a large portion of the bed being clogged, and this made the rate through the portion not clogged great enough to disturb the gravel. The sketch in Fig. 7 was from a section dug across the bed so the clogged places could be measured. It is typical of the entire bed. There is side clogging so wide on the left side of the sketch that the area has become fixed and the crack was then opening at a point about 16 to 18 in. from the wall. The sketch shows center clogged places with cracks in the center similar to the sketch in Fig. 5, and others so large they have become fixed and cracks are opening between the clogged areas and the portion not clogged.

Much that the writer has described represents extreme conditions, but it is such conditions that give the best proof of the causes for the formation of clogged areas. Everything is taken from actual conditions in a well designed and well operated filtration plant. To many who are not troubled with excessive clogging it may seem almost impossible for beds to get in such conditions, but this is what a few filter operators have to contend with in trying to operate their plants efficiently. The manganese bearing waters probably are the worst to cause filter bed clogging, but manganese is not the entire cause. Any water that produces a soft coating on the sand grains which causes the beds to settle during the run usually gives such troubles. Fortunately the coated sand appears to be more effective in removing the suspended matter from the water and even though cracks may open almost to the gravel, very little coagulated matter passes the filters. If the washing is such that the gravel is not disturbed the badly clogged beds in localities where the water temperature goes nearly to the freezing point in winter will clear themselves of most of the clogged areas, except possibly along the sidewalls.

Some are of the opinion that coarse sand of certain kinds will prevent clogging. Figure 8 shows the condition of a filter bed having sand of approximately 0.6 mm. for the 10 per cent size. This bed was constructed in accordance with what was thought to be ideal for resisting clogging, but the photograph shows that the ideal bed clogged almost as badly as those with finer sand. All of this shows there is no hope of constructing filter beds which are washed in accordance with present practice that will not form clogged places in some waters. The cause of clogging in most instances is not the design of the filters, the size and kind of sand, nor the way in which the filters are washed, but the character of water being filtered. Clogging can be remedied for such waters only by some change in the design of the filters or methods of operation especially adapted for preventing the formation of clogged areas.

Romance in Sewage Disposal

An Editorial in January Sewage Works Journal

The romantic or emotional aspects of science have in general been emphasized to a greater extent in France than in England or America. The Englishman or American in technical or scientific work is more or less prosaic and characterized primarily by curiosity or inquisitiveness rather than by lofty thoughts of his contributions to culture or humanity.

Notwithstanding this characteristic, we occasionally find writers who attempt to cast glamour over the unadorned facts of garbage disposal, sewage treatment and sludge disposal. Some of these bedtime stories are entertaining as witness the following editorial from a recent issue of The Surveyor: "The Salubrious Dump: Its Flora and Fauna."

"In an article entitled 'The Botany of Refuse' the Times deals with 'these huge, evil-smelling piles' which the metropolis has in unneighborly manner inflicted upon Home Counties' residents. But it treats the subject from an entirely new standpoint—that of the botanist, 'who finds the rubbish heaps of a great city a perennial source of interest.' The reference is particularly to the tangle of vegetation which covers the refuse within a few months of its being tipped, and it is interesting to hear that 'most of the plants in the tangle are of foreign origin, and one may find among them species from every quarter of the globe.' A list of foreign plants found in such places round London contains no fewer than 250 species, but we personally prefer to do our own botanizing on the swards and among the hedgerows of country lanes. We are content to leave the botanist in full possession of his 'sneaking affection for these dumps,' and to ally ourselves with the party to whom they cause 'such natural offense.'

"Some years ago a gentleman whose sanitary enthusiasm outran his sense of the ridiculous, wrote an article which he called 'The Romance of Sewage Disposal,' in which he pictured the dead little microbes marrying and giving in marriage, and within the precincts of their unsavory habitat multiplying by millions and thriving upon a diet of very mixed salubrity. It was just the mental pabulum for the popular weeklies which dabbed in the wonders of science among other things, and we believe that the author was commissioned to write many articles in similar vein. Regarded in the right light, there is a certain spice of romance in everything, although much depends upon the actual interpretation of the word. There may be some hidden romance in the dumps (there is at least beauty in their vegetation) but it has yet to be discovered. Meanwhile we would suggest to the gentleman who penned the Times article that he should turn his attention to the fauna of the dumps. Local color could be acquired by the simple expedient of a night spent upon them. One would be enough."

The fauna of sludge dumps was discussed at the New York meeting, as reported in this issue; a fly paper comes from California; odors have been wafted from Schenectady and Plainfield. These discussions are hardly romantic, but nevertheless such problems are familiar to most of us, and their solution usually demands true scientific research and mature engineering judgment.

Whether or not we are able to find romance in our work, the fact remains that the work must be done and we are able to find satisfaction in some of its aspects. Possibly our philosophy may best be expresed in the words of the drain man, Robert Smith, in Charles Rann Kennedy's "The Servant in the House":

"That's what I come 'ere to talk abaht—my job. P'r'aps you'll think as it ain't a tasty subjic, before a lot o' nice, clean, respectable people as never 'ad anythin' worse on their fingers than a bit o' lawn dirt, playin' crokey; but some one 'as to see to the drains, some one 'as to clear up the muck of the world; I'm the one' an' I'm 'ere to tell you abaht it."

Activated Sludge Process for Columbus, O.

Two Plans Submitted for Preventing Pollution of Scioto River

DURING the past year studies have been made under the direction of Robert A. Allton, Sewage Disposal Engineer of the Division of Engineering and Construction of Columbus, O., and John H. Gregory, Consulting Engineer, to determine the proper method for the final treatment of sewage for the city of Columbus. Estimates were submitted to R. H. Simpson, Chief Engineer of the Division, and were filed by him on Feb. 3 with the city council. The following is extracted from the report.

Statement of Problem.—To satisfactorily correct the pollution of the Scioto River and Alum Creek, due to the discharge of sewage into them by the city of Columbus, the sewage from the city must be so treated that the water in these streams will, at no time, be devoid of dissolved oxygen and so that sewage solids entering these streams will be reduced to a minimum and will not cause a nuisance.

To purify sewage, oxygen is needed. The amount of oxygen, so needed, for a given volume and strength of sewage is known as the oxygen demand of the sewage. The oxygen required to meet this oxygen demand is supplied partly by the oxygen dissolved in the water of the stream receiving the sewage and partly by some method of sewage treatment. In 1945 it is estimated that the sewage flow from the city of Columbus will have a one-day oxygen demand of about 38,500 lb. of oxygen per day and, that during periods of low flow, the water in the Scioto River can furnish only about 6,500 lb. of oxygen per day. The difference between the oxygen demand of the sewage and the oxygen supply of the river represents the quantity of oxygen which the sewage treatment works must furnish, or, stating it in another way, this difference represents the reduction in oxygen demand of the sewage which the treatment works must accamplish.

The removal of the suspended solids in the sewage by the sewage treatment works must be sufficient in amount to prevent the formation of sludge beds or scum patches in the river.

Design Date.—Experience has shown that it is economical and wise to design a sewage treatment works for conditions which will obtain, in general, from 12 to 15 years after the works are finished and placed in operation. This is not only desirable from the standpoint of cost, but has the added advantage of allowing the works to operate under a lighter load during the first years of operation and of giving a reasonably long period of operation uninterrupted by the construction of additions to the works. For Columbus conditions, the year 1945 has been selected as the design date.

Bases of Design.—The bases of design may be briefly summarized as follows:

1. The sewage treatment works are to be designed to meet the estimated conditions in 1945, with provisions for expansion to meet the estimated conditions in 1960.
2. The estimated population in the area tributary to the sewage treatment works in 1945 is 485,000.
3. The estimated average dry weather sewage flow in 1945 is 60 million gallons per day.
4. The sewage treatment works must be designed to reduce the oxygen demand of the raw sewage and to remove the suspended solids to such a degree that the discharge of the treated sewage into the river will not cause a nuisance.
5. The average treatment works shall be capable of treating a flow during storms of 200 per cent of the average dry weather flow.

Proposed Sewage Treatment Works.—Several different sewage treatment projects have been carefully studied and of these the two most desirable are briefly described below. Both of these projects are designed to treat the estimated 1945 sewage flow and to produce the results required to prevent nuisance in the river.

Project I: This project contemplates the use of the existing sewage treatment works, with modifications, for the complete treatment of a portion of the sewage flow, and the construction of additional works of the activated sludge type, at the site of the existing sewage treatment works, for complete treatment of the balance of the sewage flow.

Under this project no additional land will have to be acquired by the city and the existing works will be utilized as fully as possibly.

Project II: This project contemplates the abandonment of the existing sewage treatment works, and the construction of an entirely new sewage treatment works of the activated sludge type, at a new site farther down stream on the Scioto River, for complete treatment of the entire sewage flow.

Under this project the city will have to buy a tract of land some miles south of the present sewage treatment works and will also have to acquire a right-of-way for force-mains from the site of the existing works to the new site.

Estimates of Cost.—The estimated cost of construction of Project I, utilizing the existing sewage treatment works, is $4,000,000.

The estimated cost of construction of Project II, involving the abandonment of the existing works and the construction of an entirely new works down stream, is $6,100,000.

The estimated total annual cost of the treatment of the sewage under Project 1, including maintenance, operation and fixed charges, as of 1935, is $524,000 or $1.39 per capita per year, decreasing in 1945 to $481,000 or 99 ct. per capita per year.

The estimated total annual cost of the treatment of the sewage under Project II, including maintenance, operation and fixed charges, as of 1935, is $739,100 or $1.95 per capita per year, decreasing in 1945 to $658,700 or $1.36 per capita per year.

The above estimates of cost of construction and annual costs are summarized in the tables hereto appended.

In presenting these estimates of cost it should be stated that they are preliminary and may be subject to revision when detail contract plans have been completed.

Project I—Sewage Treatment Works—Involving the Utilization of the Existing Works

Table 1—Estimated Cost of Construction

Additional force main and connections	$ 242,000
Primary settling tanks and equipment	347,000
Sludge digestion tanks and equipment	814,000
Sludge drying beds and equipment	219,000
Activated sludge plant and equipment	1,822,000
Modification of trickling filters	182,000
Trickling filter settling tanks	86,000
Buildings, laboratory and equipment	72,000
New levee and moving existing levee	107,000
Grading, roads, drains, water mains, lighting, etc	109,000
Total estimated cost of construction	$4,000,000

Table 2—Estimated Annual Cost, Including Maintenance, Operation and Fixed Charges

Item	Total	Cost per Capita
1935—		
Fixed charges	$340,000	$0.90
Maintenance and operation	184,000	.49
Total	$524,000	$1.39
1945—		
Fixed charges	$268,000	$0.55
Maintenance and operation	213,000	.44
Total	$481,000	$0.99

Project II—Sewage Treatment Works—Involving the Abandonment of the Existing Works

Table 3—Estimated Cost of Construction

Additional force main and connections	$1,756,000
Primary settling tanks and equipment	347,000
Sludge digestion tanks and equipment	1,031,000
Sludge drying beds and equipment	256,000
Activated sludge plant and equipment	2,430,000
Buildings, laboratory and equipment	72,000
Grading, roads, drains, water supply, lighting, etc	128,000
Land	80,000
Total estimated cost of construction	$6,100,000

Table 4—Estimated Annual Cost—Including Maintenance, Operation and Fixed Charges

Item	Total	Cost per Capita
1935—		
Fixed charges	$518,500	$1.37
Maintenance and operation	220,600	.58
Total	$739,100	$1.95
1945—		
Fixed charges	$408,700	$0.84
Maintenance and operation	250,000	.52
Total	$658,700	$1.36

Instructions for Filter Attendants

Rules and Regulations for the Guidance of the Employees at the Montebello Filters of the City of Baltimore, Md.

By JAMES W. ARMSTRONG
Filtration Engineer, City Water Department, Baltimore, Md.

With the semi-skilled labor usually employed for operators or attendants in filtration plants, it is necessary to have specific instructions as to the work each employee should do and to insist on a rigid observance of the instructions. To outline the duties of the various employees is not a simple task.

Some 12 or 13 years ago, Mr. Armstrong got up instructions for the operators at the Montebello Filters. The instructions have been changed from time to time to make them cover more specifically the work to be done. Paragraphs that were useless or could not be complied with were cut out and new paragraphs added where it was seen that the instructions did not fully cover the duties. The instructions as now written constitute a very concise and specific outline of the duties of the various employees. There is no need of having instructions to tell the operators how to enter records on the operating sheets furnished them, for they know that this must be done.

These instructions are for the operators of the Montebello Filters and are not applicable without change to other plants, but they serve as a model for those who may wish to get up similar instructions. The writer was associated with Mr. Armstrong at the Montebello Filters for 10 years and during that time had much to do with the enforcement of the instructions. They are practical, and leave very little room for argument as to whose duty it is to perform certain work.—John R. Baylis, Associate Editor.

Instructions for Controller Attendants

Chemical Feed Controllers.—1. Chemical feed controllers shall be used alternately for a period of one month.

2. After throwing a controller out of service, it shall be thoroughly cleaned and put in readiness for future use. Flush the tank and nozzle with clean water, but do not take the nozzle apart.

3. It shall be the duty of the attendant retiring from duty on the second watch to make the necessary changes and clean the controllers thrown out of service.

4. Stir the sludge in both lime and alum controller feed tanks at frequent intervals. This is particularly important in the lime tanks.

5. In changing the controller rate of discharge, always turn the pointer past the desired point of setting toward the zero mark, and make the final adjustment by turning the pointer away from the zero mark. Failure to observe this will result in inaccuracy of discharge.

6. At least once each watch, flush the nozzle of the controller in service by opening it wide, and immediately afterward adjusting to the required opening.

7. Always disconnect all nozzles not in service and lower them carefully to rest. The nozzles are expensive and failure to lower them carefully may result in breaking them. Remove the weight from the lower lever arm of all chemical feed controllers not in service.

8. Keep an eye on the small bronze cables that actuate the nozzles. They should be taut at all times. A slack cable means that something has gone wrong.

9. See that the sliding clamp at the pinch valve is kept clean and greased at all times.

Application of Lime.—10. The application of lime shall be controlled entirely by the pH machine, so that a value of 8.2 shall, as nearly as possible, be maintained in the water leaving the plant. In event of trouble with the pH machine, the filter attendant will make pH determinations by the color method and report to the controller attendant.

11. The pH machine should be examined every half hour to see that the correct amount of lime is going into the water.

Application of Alum.—12. The rate at which alum is applied to the water will at all times be determined by the chemist. Should the water be insufficiently coagulated at a time when the chemist is not on duty, increase the dose slightly and immediately notify him if he can be reached by telephone.

Equalizing Alum Solution.—13. In filling the solution tanks in the old plant, a depth of 3.75 ft. of 10 per cent solution should be admitted from the boiling tank. It should then be immediately diluted to a depth of 15 ft. in order to prepare a 2½ per cent solution for supplying the feed controllers.

14. Before withdrawing solution from the boiling tanks at the new plant, be sure that the solution is thoroughly agitated, but before opening the valves for its withdrawal, be sure that the air is cut off. Failure to do this will result in excessive corrosion of pipes.

15. After the requisite amount of 10 per cent solution has passed over to the old plant, always open the flushing valve wide and leave it open for a period of from 15 to 20 minutes, in order to entirely clear the 4-in. pipe line of all alum solution.

Agitation of Chemical Solutions.—16. Use only sufficient air to give the alum solution a slight agitation.

17. If no alum is being made or solution fed from the new plant, stop the air compressors.

18. Start the lime agitators about an hour, and the alum agitators about 15 minutes before tapping a new tank. Let the agitators run continuously as long as chemicals are being withdrawn. This is especially important with the lime.

Log Book.—19. Note in the log book the time of tapping and emptying of each tank. If for any reason the strength varies from 2½ per cent, or the depth varies from the 15 ft. in the old plant, or the established depth in the new plant, make a special note stating the facts.

Float Tubes.—20. The float tubes for actuating the chemical recording gauges are designed for operation with clean water, and it is very important that the chemicals be kept out of these tubes and the piping connecting the float tubes with the solution tanks.

21. In order to prevent the solution from entering the float tubes, the small valve connecting the tank with the tubes should be closed during the time of mixing solution, and the valve opened, admitting pressure water into the small piping. When the tank is ready to be thrown in service, the pressure valve should be closed and the other valve opened.

Gauges and Charts.—22. The charts of the daily recording gauges should be changed as near midnight as possible.

23. Always observe carefully the time and see that the chart is started correctly.

24. Use as much care as possible in placing charts to see that the ink is not spilled from the pens. Be careful not to pull the pen arm back too far, as to do so may injure the instrument and impair its accuracy.

25. Simplex Valve & Meter charts should have their bottom edges coincide exactly with the bottom of the cylinders.

26. In interpreting the meter charts and the filtered water level gauge, an allowance of about 20 minutes should be made at the time of changing rates for the lag in the movement of the pen due to the large float tubes.

Clock Winding.—27. Wind all clocks each Monday and Thursday.

Samples.—28. Samples of water from the entrance to the coagulating basins shall be put in the large beakers once each hour on the hour.

29. Raw water samples shall be taken once each watch. If the water is bad they shall be taken each hour.

30. Every two hours, approximately on the even hours, a sample shall be taken from coagulating basins Nos. 1 and 3, and the filtered water conduit of the new plant and put in the large composite sample bottles.

31. A bacterial sample of the combined filter effluent shall be taken from the filtered water conduit of the new plant at 2 A. M. and 8 P. M.

Elevator.—32. Do not use the elevators for passenger service, except when it is necessary to go to the top floor of the tower.

33. Always start and stop the elevator by means of the rope. Never by the little switch.

34. Never suddenly reverse the direction of the elevator; always come to a full stop before changing the direction.

35. Always close the safety gate and shut the outer doors before starting and upon leaving the elevator.

Valves.—36. Open and close all valves gradually, especially those on the pressure system. Suddenly stopping the flow of water in a pipe results in water hammer. Water hammer causes leaky joints and trouble with valves.

37. Do not use wrenches for closing valves. Much injury has been done to valves by improper handling. If a valve cannot be closed properly by hand, without forcing, report it as being out of order.

38. When difficulty is encountered in closing valves due to the accumulation of grit or sludge in the bottom of the body, the seat can often be freed from obstructions by moving the discs slowly up and down a few times before closing. In case of the 12-in. lime valves, the seats can be inspected.

Liquid Chlorine.—39. Never change the percentage of liquid chlorine from the amount shown in the table without orders from the chemist.

40. Every two hours, on the even hour, a record should be made in the chlorine book of the weight of chlorine on the scales and the rate of application. The midnight reading should be taken immediately after changing the Venturi meter chart, so that the correct amount used for the calendar day can be computed.

41. As nearly as possible, on the hour of every odd hour, the Venturi meter should be examined to see whether the rate of flow has changed sufficiently to warrant any change in the application of chlorine.

42. Whenever the rate of flow changes, the proper change should be made in the amount of liquid chlorine added to the water, and the weight should be recorded so that the performance of the apparatus can be checked.

43. When new cylinders are added, be sure and record the total weight immediately before and after placing.

44. Never turn on more cylinders than enough to keep the pressure up to the required amount. In opening cylinders begin on the left hand side when facing the scales, and open them in succession toward the right, one or two at a time as they may be needed.

45. Should trouble be experienced in maintaining the required rate of flow from the chlorine apparatus, make sure that all cylinders are turned on and the proper valves are all open. If in cold weather, be sure that the room is at the proper temperature. If these remedies fail, notify the chemist at once.

46. Keep the temperature of the cylinder room above 70° F. and the hand on the pressure valve as near 25 lb. as possible.

47. Whenever the smell of chlorine is detected, a careful test should be made at once to determine the source. Should a leak occur in a joint, the joint should be immediately tightened. Should a leak require the attention of a mechanic, cut out if possible, the defective apparatus and notify the mechanic at once.

48. Keep the doors to the chlorine room shut at all times, and the windows in the cylinder room shut.

Manhole Covers.—49. Always replace manhole covers and spout hole covers as soon as the requirements of service permit. Never leave any manholes open, especially in the tower.

Lights.—50. Use all the lights necessary for doing your work properly, but do not burn useless light. Turn out all lights when through with them, except the few required for general illumination.

In General.—51. The retiring attendant shall inform the one reporting for duty of anything requiring his attention.

52. The reporting attendant, upon taking charge of a watch, shall examine all gauges and apparatus of which he has charge, in order to assure himself that everything is working satisfactorily.

53. Should any of the gauges, valves, or other apparatus become out of order, do not attempt to repair them, except in the case of minor troubles such as slipping of cables from the pulleys, the tightening of nuts, etc Make a record in duplicate of repairs requiring the services of a mechanic on the slips provided for the purpose.

54. In case of an accident requiring immediately attention, notify the mechanic and afterwards make the report.

55. It shall be the duty of the operator on the second watch to keep the pens clean and in good operating condition.

INSTRUCTIONS FOR FILTER ATTENDANTS

First Consideration.—1. The first consideration in operating the filters is to see that sufficient water is delivered to the city at all times, and the second is to see that the quality of the water is the best that can be delivered. With both of these factors the filter attendant has much to do.

Control of Water.—The quantity of water delivered, of course, depends upon the amount being used by the city. In order to be prepared to meet the city's need in the safest way, the water level in the filtered water reservoir should be kept as high as possible at all times. To do this, the filters should be kept clean and capable of delivering their maximum output, and the pumping rate should be kept closely to the filtering rate. While it is not practicable to do this exactly, for the reason that an economical pumping combination does not always coincide with the filter requirements; the filter attendant should carefully study the different pump combinations with the object of securing the best operating results. The pumping station operators can give the most economical pump combinations for securing different rates of flow. The skill of the attendant in achieving the above results can be judged in a large measure by the regularity and evenness of the lines on the Venturi meters and filtered water level charts. The plant should be operated so as to prevent high peak loads.

Water Level.—3. Filter attendants should endeavor to keep the water level of the filters at least 4 in. below their top, and if possible, never let it drop more than 4 in. below the bottom of the walks. In order to secure the most economical rate of pumping, it may be at times necessary to let the water drop somewhat below the level stated above, but it should be brought back to the proper level as soon as possible.

Improper Coagulation.—4. Improper coagulation is sure to give inferior results, and while the attendant is not responsible for the application of chemicals, he should be the first one to discover any deficient coagulation. By immediately reporting to the chemist the slightest appearance of insufficient treatment, the filter attendant may be a great help in maintaining a high plant efficiency. If the chemist is not on duty, report improper treatment of the water to the controller attendant.

On Washing Filters.—5. It is not possible to give specific instructions for washing filters that will apply at all times. The quality of the filter effluent, and the rate of flow, are the only factors to be used in determining whether or not a filter needs washing.

Sight Glasses.—6. The sight glasses should be used for determining the time for washing a filter. If the water in the glass appears slightly turbid, it is evidence that the filter needs washing.

Rate of Flow.—7. If the rate of flow from any filter drops much below that of the other filters, due to clogging of the sand surface, it should be washed, regardless of the quality of the effluent. Reduced rate of flow may be caused by long filter runs, high turbidities, the presence of large numbers of organisms or organic matter in the water.

Loss of Head.—8. The loss of head curve should not of itself be used as a washing but as the loss of head increases, it should be used as a signal for examining the sight glass.

Length of Runs.—9. The length of filter runs will vary greatly from time to time, and should never be used as an index for washing. In case of an unusually long run, the chemist's attention should be called to the fact.

Order of Opening Valves.—10. Before starting to wash, the influent valve should be closed and water should be allowed to filter down to within a few inches of the sand level. Then the butterfly and effluent valves should be closed, afterwards the 30 in. drain valve should be opened and then the 24 in. wash water valve should be opened.

Filters Out of Service.—11. Plan the washing of filters so that no more than two filters will be cut out of service at the same time.

Draining Below Sand Surface.—12. Do not drain the filters below the sand level. If for any reason the water in any filter drains down below the sand level, air will be drawn into the sand bed and when the wash water is applied, a thick tough foam will be formed to which considerable sand adheres that will be carried away with the wash water.

Operating Wash Water Valve.—13. In opening the wash water valve, it should be done very gradually until the top layer of sand has been thoroughly broken, then the valve should be opened the full distance to secure the necessary rate of wash. Should air bubbles escape from the sand, special care should be taken to admit wash water slowly. Failure to observe these precautions may result in a "blow out" of the filter bed.

After Washing.—14. Immediately after washing, the filter should again be put into service. The 24 in. influent valve should only be opened a distance of about 6 in. until the filter tank is full, when it should be opened wide. Failure to follow this precaution will cause ridging of the sand.

After the water has reached the normal level, the effluent valve should be opened about 6 in. and the filter should be allowed to operate for about one hour; afterward, it should be opened wide. It is important to start filtering at a slow rate.

Duration of Wash.—15. The duration of wash shall be determined by the turbidity of the waste water entering the troughs. Do not wash until the water flows entirely clear; a slight turbidity at the close of the waste is desirable. The time of wash to be recorded shall be taken from the instant the water overflows the gutters, until the operating lever controlling the wash water valve is reversed.

On Putting New Filters Into Service.—16. If for any reason the water should be drained from beneath a filter, do not fill it by admitting water through the influent valve, but fill it by admitting water slowly through the wash water valve. When the air has been driven from the sand bed, water should be admitted in the usual way.

During the Wash.—17. The filter attendant should spend the best part of the washing period walking over the filter observing effects of the wash, and he should not leave the filter being washed until the influent valve is opened and the filter is again ready for service.

Boosting.—18. Boosting of a filter should never be resorted to unless by special instruction.

Wash Water Pump.—19. Only run one wash water pump at a time.

Wash Water Tanks.—20. Keep the wash water tanks full and ready for service. Do not empty the wash water tanks unless by special instruction.

In General.—21. The retiring operator shall inform the one reporting for duty anything requiring his special attention.

22. The reporting attendant shall examine all charts, see that they are registering correctly, and note any filters that need washing.

23. Any irregularities in the performance of the filters should be reported at once to the chemist.

26. The Venturi meter chart must be changed promptly at midnight, and the other charts as near that hour as possible. Note any variation from the correct time or irregularities in operation on the charts removed. In placing charts be sure that they are set at the correct time, and that there is no lost motion on the dial. The Simplex meter charts should have their bottom edges coincide exactly with the bottom of the cylinder.

27. Before placing the rate of flow-loss of head charts in the new filter plant, see that the pens are properly adjusted; that the loss of head pen is not slightly above and the rate of flow pen slightly below the scratch on the dial. Failure to do this may result in injury to the instrument.

28. It shall be the duty of the attendant on the second watch to keep the pens clean and in good operating condition.

29. If a sight glass loses its water, it shall be the duty of the filter attendant to immediately refill it with water and start the siphon.

30. Whenever the pressure drops below the amount necessary to open the hydraulic valves, the attendant shall start the booster pump and run it so long as it may be required for washing.

31. It shall be the duty of the filter attendants to keep the operating tables and sight glasses in a spotlessly clean condition. They shall also keep the floors clean, and the mud and algae growths removed from the wash water troughs and sides of the filters. A little furniture polish should be used occasionally on the wooden doors, but no furniture polish or oil should be used on the marble.

32. Samples shall be tested for pH every hour.

Samples shall be tested for residual chlorine every two hours.

Work of Wisconsin Sanitary Bureau in 1929

The State Bureau of Sanitary Engineering made 667 investigations in Wisconsin during 1929, 88 more than the preceding year, according to the report of the bureau to the State Board of Health.

Industrial waste investigations increased from 179 in 1928 to 246 in 1929. Stream surveys were made along the lower Fox, Wisconsin, Flambeau, Oconto, Peshtigo and Menomonee rivers through the co-operation of the chemists of paper mills. Further surveys of the Rock, Crawfish, Fox (Illinois tributary), upper Milwaukee, Sheboyagan, Fond du Lac and Wolf rivers will be made.

A comprehensive survey of waste conditions in virtually all pulp and paper mills was completed.

Since the treatment and satisfactory disposal of milk plant wastes constitute a major problem in Wisconsin, a careful investigation of five methods of treatment has been conducted by the bureau at De Forest, Wis. These studies and observations, the report said, show the feasability of efficient and economical treatment of milk plant wastes by means of a type of filtration system, plans for which have been prepared by the department for use of operators.

During the year plans for municipal incinerators for garbage disposal were approved for Racine, Oshkosh and Whitefish Bay. Plans for a swimming pool for Black River Falls were also approved.

The Iron Removal Plant at Albuquerque, New Mexico

Unusual Water Problems Being Handled Very Satisfactorily in the New Plant

By F. M. VEACH

With Black & Veatch, Consulting Engineers, Kansas City, Mo.

THE treatment plant, which has been operating a little over a year, includes two mixing basins of the tangential flow type, in which the necessary agitation is afforded by the motion of the water itself, two settling basins, two filter units of the gravity type and chemical feeding equipment for lime, alum and chlorine.

The capacities of the various units, based on a normal flow of 5,000,000 gal. per day are as follows:

Mixing basins, 10 minutes each.

Settling basins, 1.5 hours.

Filters, 874 sq. ft. of filter surface, with control piping and valves arranged for operation at a rate of 4 gal. per square foot per minute, or approximately double the conventional filtration rate.

Clear water storage. Only 200,000 gal. are provided at the plant since the city has 13 million gallons of storage in high lever reservoirs.

The principal chemical treatment consists of the use of lime for the removal of carbon dioxide and iron as well as for partial softening, but a small amount of alum is used, as an aid to filtration.

Chlorine is not regularly used since numerous bacteriological tests have shown it unnecessary. Equipment for chlorination is set up in the plant and a supply of chlorine is kept on hand for emergency use.

Iron Removal with Lime.—A departure from the usual method of using aeration for carbon dioxide removal has been adopted here, since it was found that the additional lime required for this purpose is less expensive than the additional pumping head required for the operation of an aerator.

In routine operation lime is fed by means of a dry feed machine, into one of the mixing basins. After mixing, the water flows to the settling basins when the greater part of the iron is precipitated. From the settling basins the water flows through a second mixing basin, where a small dose of alum is added, and on to the filters. It has been found that the iron may be removed completely by the use of from .7 to 1 grain of lime and that sufficient floc for filtration may be obtained with from .1 to .2 grains of alum per gallon of water.

A limited amount of softening is possible with this plant and as a matter of fact from 10 to 15 per cent of the total hardness of the water is removed by the treatment given the water during the past few months, which has consisted of 2.7 grains of lime and .2 grain of alum per gallon.

The Water Supply.—The water supply of Albuquerque is taken from five systems of wells, all of which are located within the city limits and tap what is probably the underflow of the Rio Grande River. The hardness and iron content of the water as well as the yield of the wells in the five systems varies widely, as shown in Table I, and there also seems to be a trend toward increased hardness in most of the wells, as shown by the difference in the results taken during July, 1926, and November, 1929.

Water of varying hardness can be obtained by using various combinations of these well systems as shown in Table II.

Tests.—This shows that the production of softer water at this particular plant is largely a matter of selection and the use of so many varying kinds of water complicates the treatment problem somewhat. Frequent tests are necessary to determine the character of the raw water and the effect of treatment. These tests, which consist of alkalinity and permanent hardness determinations, are made at Albuquerque daily, or oftener if the raw water combination is changed and the chemical feed is checked at intervals of two hours. This record is kept on a daily log sheet together with the record of flow through the plant and filter record. The daily log sheets are summarized each month on a form which shows at a glance the total and average daily amount of water treated, the chemicals used and the effect of treatment.

The December operating record, for instance, showed that a treatment of 2.7 grains of hydrated lime and .2 grains of alum per gallon of water removed all of the iron and 42 p.p.m. of hardness (or 13 per cent of total hardness) from the water at a cost for chemicals of $3.70 per million gallons.

This plant is operated by one man during the daylight shift, and during the night one of the pump house employees makes regular trips to keep the hoppers of the chemical feed machines full and to see that the plant is operating properly.

The city is at present prospecting for an additional supply and hopes to get a softer water. This seems possible since several supplies exist. The Santa Fe, for instance, has three wells which furnish water with from 76 to 140 p.p.m. of total hardness and several of the laundries have similar supplies.

As stated above, this plant has been successful in the removal of iron and carbon dioxide and has gone about as far into the softening end of the game as is advisable.

Acknowledgment.—The foregoing is an abstract of a paper presented before the Rocky Mountain Section of the American Water Works Association.

Table I

Wells	Date of sample	Alkalinity of temporary	Non-carbonate or permanent	Total	Iron	Probable yield in gallons per minute
Kent Sturgis	1926	134	189	323	1.8	550
Kent Sturgis	1929	154	256	410	.2	
Broadway	1926	127	285	412	2.9	200
Broadway	1929	126	316	442	7.0	
Mountain Road	1926	132	55	182	0.1	625
Mountain Road	1929	134	88	222	Trace	
5th & Mt. Road	1926	200	84	284	.3	925
5th & Mt. Road	1929	172	74	246	Trace	
Plant Wells	1926	145	52	197	.6	500
Plant Wells	1929	138	172	310	Trace	

Table II

Well Systems in Use	Probable Yield, Gallons per Minute	Alkalinity or Temporary Hardness	Non-carbonate or Permanent Hardness	Total Hardness
1. Broadway	200	126	316	442
2. Kent Sturgis	550	154	256	410
3. Mt. Road	625	134	88	222
4. 5th & Mt. Road	925	172	74	246
5. Plant Wells	500	138	172	310
All wells	2,800	151	149	300
1, 2, 3, 5	1,875	140	187	327
2, 3, 5	1,675	141	171	312
2, 3, 4, 5	2,600	152	137	289
3, 4, 5	2,050	152	104	256
3, 4	1,550	156	83	239

Trunk Main Surveys and Distribution Studies

Use of Pitometer in Securing Data on Normal Flow of Water in Large Feed Mains, Together with Tests of Cement Lined and Talbot Lined Pipe

By H. E. BECKWITH

District Manager, the Pitometer Co., Harrisburg, Pa.

AS a natural result of the measurements made for water waste control, a considerable field has recently been developed for the use of the pitometer in securing data on the normal flow of water in large feed mains, the test on such mains to determine the Williams and Hazens coefficient, and in short to secure all other similar data which might be of value in the design of additions or reinforcements to the system. Investigations of this nature are known as trunk main surveys and distribution studies.

It is believed that illustrative cases will best serve to show the nature of the data secured in making these surveys, and its value to the engineer and operator. Besides which, this paper is not intended as a technical treatise. Its sole purpose is to call your attention to some conditions we have found, in the belief that our experiences may perchance help you in solving some problems of your own. The following example of conditions discovered by our company were discovered by different men, and are so chosen as to represent possible conditons in various parts of the country.

Normal Flow Disturbed by Closed Valves.—One of the engineers found the following interesting condition (Fig. 1) in a city of some 50,000 population. The city theoretically was being fed through two 20-in. mains, one 12-in. main, one 10-in. main, and some 6-in. mains. One of the 20-in. mains was found to be shut off by a valve broken closed, and the other was found to be shut off due to the fact that a valve on it closed by turning in a direction opposite to that of the rest of the valves in the system. As a result, the city was being fed through one 12-in. line, one 10-in. line and three 6-in. lines. This condition had prevailed for at least six years. Upon the opening of these 20-in. lines, the pressure at a fire station in the city which had been 40 lb. was increased to 75 lb.

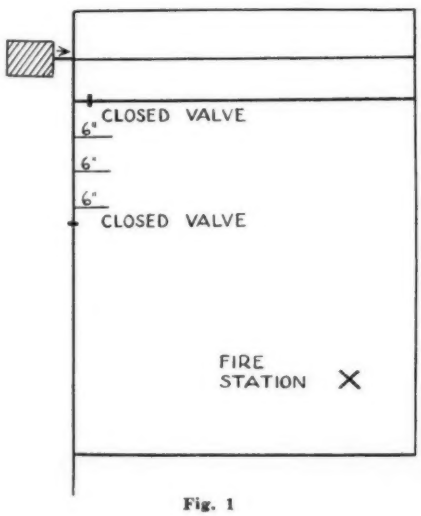


Fig. 1

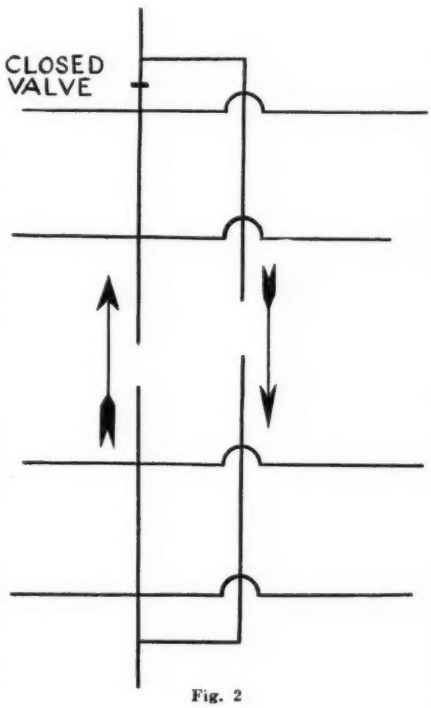


Fig. 2

Another similar instance was found in the course of our investigation in one of this country's major cities. Two widely separated portions of the system were connected by a 16-in. loop line, which line also served as a main feed for the territory in between. Along the length of this line, twelve valves were found closed, with their by-passes open, thereby practically nullifying the valve of this connection.

About a year ago a study (see Fig. 2) was being made of the existing conditions at the Allegheny Water Co. at Altoona, Pa., with a view to strengthening the system. This system, which supplies several small communities, is essentially one long feed main with laterals leading off to each side. At one point, this feed main had, for 1½ miles of its length, been paralleled by another main which was not connected to any of the laterals and which was only connected to the original feed main at the two ends. In plotting the hydraulic grade line along this stretch, it was found to be lower along the pipe than at either end of the paralleled section. This was caused by the valve on the reservoir end of the "old" line being closed and all water being compelled to flow through the new line to the point of their connection 1½ miles away and then flow back toward the closed value. As is usually the case, the reason for this valve being closed was that it operated contrary to the majority of the valves in the system.

In each of these instances the normal flows were disturbed by closed valves. But our investigations often lead to the discovery that the maximum efficiency of the lines is not reached because of other reasons.

There was, for instance, one main feed line which was not doing any work because at one point it lay above the level of the water in the reservoir from which it fed.

Increasing Capacity by Equalizing Loads.—Then there is the case (Fig. 3) of the two 48-in. lines which supply West Philadelphia with low pressure water from the Belmont filter plant. Our test at the inlet end of these pipes showed a maximum velocity in

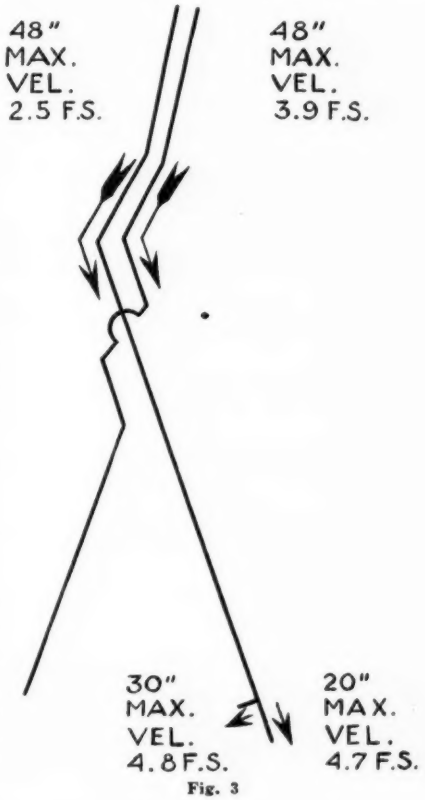


Fig. 3

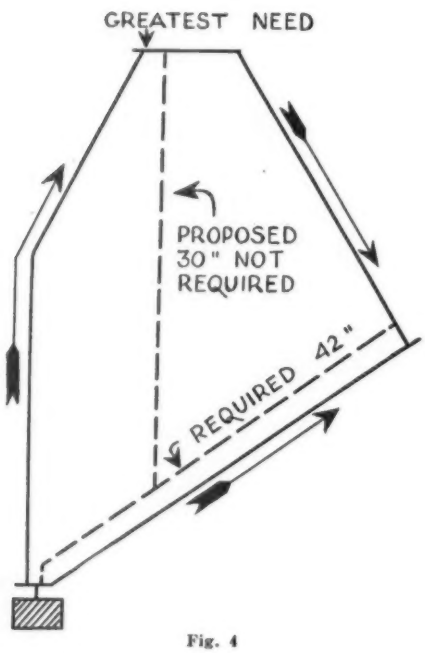


Fig. 4

one of 2.5 ft. per second, and in the other a maximum velocity of 3.9 ft. per second. Our investigations showed that this inequality in flow was caused by a choking of the pipe having the lower flow. This occurred at Belmont Road and Montgomery Ave. At this point the 48-in. main was broken up into a 30-in. main having a maximum velocity of 4.8 ft. per second, and a 20-in. main having a maximum velocity of 4.7 ft. per second. The carrying capacity of these two mains was considerably less than the capacity of the 48-in. main feeding them, and the large main was therefore unable to work at its maximum capacity. By adequately connecting the two 48-in. lines at the point where the one breaks up into the two smaller mains, the load would be equalized and the carrying capacity of the installation considerably increased.

How Equal Distribution of Load Was Secured.—A situation the reverse of this was discovered in Pittsburgh, through our tests on the two 20-in. mains which convey water from the Herron Hill Pumping Station to the Squirrel Hill District. These mains are of approximately the same length, the same age, and our tests showed them to have approximately the same Williams and Hazens coefficient. Yet our measurements showed a maximum velocity in one of 1.54 ft. per second, and in the other of 2.80 ft. per second. This inequality of flow was found to be caused by unequal feeds to the two mains at the pump statlion. One main was fed by a 20-in. connection and a 16-in. connection, whereas the other main was fed by one 12-in. connection. By increasing the feed to this latter main, the load will be equally distributed and the friction loss considerably reduced.

The conditions of flow (Fig. 4) found to exist in the 30-in. Hawley-Forest-Detroit-Nesselwood-Erie-Cherry Broadway loop in Toledo illustrate a somewhat different variation of the same thing. An automobile factory is situated on that part of the loop furthest from the pumping station. The underwriters' tests showed the flow of water at this point to be insufficient and the system in need of reinforcement. It had been supposed that the point of equalization of flow in this loop was at the automobile factory. Our tests, however, showed that the flow equalized at a point on the loop much closer to the pumping station. The plans for reinforcements had provided for a 42-in. line from the pumping station to the point found to be the real point of equalization, and a 30-in. line to be taken off this proposed 42-in. line at a point near the pumping station and running to the general location of the automobile factory. However, a study of the conditions as shown by our tests proved that, after the 42-in. line was built as planned, the flow between the present point of equalization and the automobile factory would be reversed so as to feed toward the factory, and thereby furnish a supply entirely adequate to meet the demands for fire protection. The contemplated 30-in. line was thereby proved to be unnecessary, and its cost saved.

Of considerable importance also are the tests on the main feed lines for loss of head and the determination of the value of the Williams and Hazen coefficient. All waters do not tuberculate pipe at the same rate, and it is of considerable value to make tests at each plant to determine exactly what the effect of the local water is on the mains. These values will often be found to vary widely from the values given in tables at present available.

Tests of Cement Lined and Talbot Lined Pipe.—In order that the results of certain tests made last spring at the plant of the National Tube Co. at Versailles, Pa., may be made available to the profession, it has been requested that they be included in this paper. These tests were made to determine the carrying capacity of new cement-lined and of new "Talbot"-lined pipe. The preparations for the tests were costly and were of such a nature as to make them practically laboratory tests. The following extract from the report on this work gives the details and results.

The general layout of the piping for this test is shown in Fig. 5.

The water was pumped from a tank by means of a centrifugal pump driven by a variable speed motor. It first passed through about 1,500 ft. of pipe laid perfectly straight and perfectly level. Then by means of two 90 deg. bends the direction of flow was turned back toward the tank, and the water passed through another 1,500 ft. of straight, level pipe back into the tank from which it was first pumped. For purposes of comparison the two sections of the main were Talbot-lined and cement-lined pipe respectively. Velocities were varied by varying the speed of the pump. While these sections of pipe were each 1,500 ft. in length, only 1,000 ft. of each was used in the tests, the extra length being laid so that all eddies and turbulence of flow would be eliminated before the water reached the test section. The diameters used were those of the interior of the lining, and were determined by calipering the pipe at the gauging points.

The velocities were measured by a pitometer, while the loss in head was measured by a mercury filled manometer. Pressure was transmitted to the manometer from the ends of the test section by means of ½-in. piping, all necessary flexible connections being made by rubber tubing.

It was impossible to obtain flows under 2.56 ft. per second, as the pump set up a surge when throttled below that point.

Several tests were run until everything was co-ordinated and working smoothly. Our official tests, therefore, start with Test No. 6. All computations were made with the slide rule.

The results of the tests are shown in Table I.

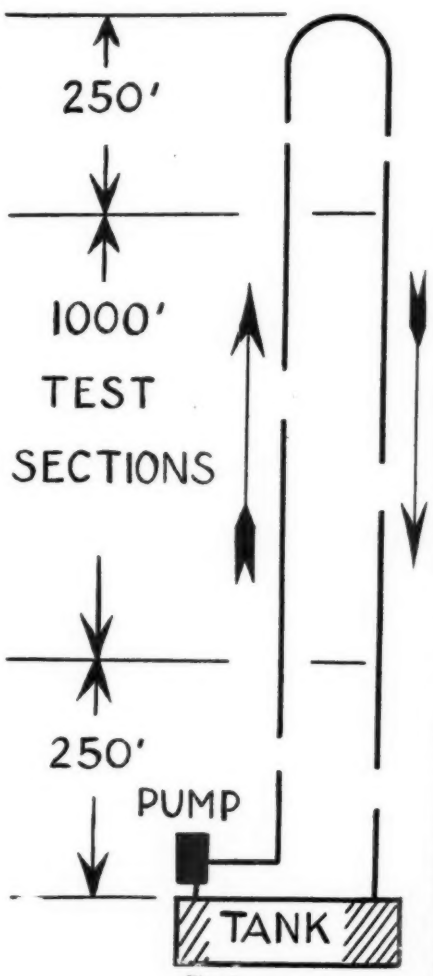


Fig. 5

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Table I—Results of Tests of Talbot Lined and Cement Lined Pipe

	Talbot Lined Diameter 11.31 In. Ratio of Average Velocity to Center Velocity 88.6% Length of Pipe Under Test 1,000 Ft.			Cement Lined Diameter 11.44 In. Ratio of Aevareg Velocity to Center Velocity 84.8% Length of Pipe Under Test 1,000 Ft.		
No. Test	Velocity in Feet per Second	Loss ofHead in Feet	Williams & Hazen Coeff.	Velocity in Feet per Second	Loss of Head in Feet	Williams & Hazen Coeff.
12	2.60	1.63	158	2.56	1.70	150
11	3.63	3.01	158	3.58	3.21	149
10	5.08	5.65	158	5.01	6.06	148
6	5.74	6.87	160	5.63	7.57	148
7	7.01	9.95	160	6.87	10.88	148
8	8.36	13.90	158	8.20	15.38	147
9	9.42	17.40	159	9.24	19.35	147

No Talbot lined pipe has been installed long enough to make possible tests on installations which have been in service over any considerable period of time. You may, however, in view of the present attention being given to cement-lined pipes, be interested in some tests recently made on cement pipe at Greensburg, Pa. This pipe is built of an inside layer of cement, then a layer of wrought iron, then a layer of cement, and then another layer of wrought iron. This pipe was laid in 1888, so that the tests show the effect of 41 years of service. Long lengths of this pipe were laid for conduit purposes and made ideal subjects for tests. The water carried is a mountain water and the pipe is laid over moderately broken territory.

Tests of Cement Lined Pipe.—These tests were made under service conditions and the losses include losses from bends, etc. The flows were measured with the pitometer and the friction losses measured by carefully calibrated Bristol recording gauges. Two pieces of pipe were tested, one 14-in. pipe 12,581 ft. in length, and one 12-in. pipe 7,854 ft. in length. In both cases the Williams and Hazen coefficient was found to be 105. These tests were made by Mr. Guy Morrow and Mr. John Kelliher of the Community Water Service Co., and it is through their courtesy that I am able to pass this information on to you. The details of the tests follow:

Loss-of-Head Test of the Wetsmoreland Water Co. Made Sept. 21, 1929

Fourteen-inch cement line from Immel Reservoir and a Determination of "C" in Hazen & Williams formula

Flow Measurements

Location	Pitometer Size Coefficient	Consumption G. P. D.
Sta. 0-1+73	14"—86%	1,684,000
Sta. 124+08	14"—82.55%	1,671,000

Waste 13.000 G. P. D.

Loss-of-Head Test

Location—0-1+73		124+08
Size—14"		14"
Velocity—2.55	Average 2.54	2.53
Elevation—1401.91		1140.87
Water Level—1417.52		1384.61

Total Loss—32.91
Length—12,581 Ft.
Loss per 1000—2.616
Coefficient—105
Pipe Diameter 13 13/16
Date laid, 1888

Loss-of-Head Test of the Westmoreland Water Co., Sept. 21, 1929

Loss-of-Heal Test and a determination of "C" in Hazen & Williams formula. Was made on 12-in. cement-lined from a point below Dry Ridge Reservoir to a point near the Jamison Venturia Meter with the following results:

Flow Measurements

Location	Pitometer Size Coefficient	Consumption G. P. D.
Sta. 375+46	12"—0.83	1,313,000
Sta. 451+00	12"—0.79	1,228,000

Loss 85,000 G. P. D.

Loss-of-Head Test

Location—Sta. 375+46		Sta. 454+00
Size—12"		12"
Velocity 2.687	Average 2.597	2.508
Head—130		107.5
Elevation—1170.14		1167.48
Water Level—1300.14		1274.98

Total Loss—25.16
Length—7854
Loss per 1000—3,203
Coefficient—105
Date laid, 1888

Acknowledgment.—The foregoing is an abstract of a paper presented at the 84th annual meeting of the Pennsylvania Water Works Association.

Famous Hydraulic Engineer Dies

Clemens Herschel, one of the most prominent hydraulic engineers of this country, died March 1 at his home in Glenwood, N. J., after a short illness. His health had been impaired during the last few months, but until quite recently he went to his office at 2 Wall St., New York City, with regularity.

Mr. Herschel was born in Boston, Mass., on March 23, 1842. He was graduated from the Lawrence Scientific School of Harvard University in 1860. He first engaged in bridge designing and construction and later was employed on the sewer system of Boston. Later he turned his attention to hydraulic engineering and from 1879 to 1889, as engineer for the Holyoke Water Power Co. of Holyoke, Mass., did much research and made many developments in the field of water power, including the famous Holyoke testing flume, which marked the beginning in the scientific design of the modern water power wheels. During this period he also made the designs for the masonry dam across the Connecticut River at Holyoke. Mr. Herschel was engineer and superintendent of the East Jersey Water Co. from 1889 to 1900, during which time he developed a water supply for Newark, N. J., and vicinity.

Since 1900 Mr. Herschel had served as consultant in many important water projects, including the Niagara Falls power problem. He was one of a commission of three engineers who examined the plans for the city tunnel of the Catskill Aqueduct in New York City in 1910 before they were approved by the Board of Estimate.

Mr. Herschel was the inventor of the Venturi meter, being awarded the Elliott Cresson gold medal of the Franklin Institute for this invention.

Mr. Herschel was vice-president of the American Society of Civil Engineers in 1915 and president in 1916. He wrote several books on hydraulics, notably a translation from "Frontinus, and the Water Supply of the City of Rome," which he compiled from notes and plans of Frontinus found in an old monastery.

New Water Supply Proposed for Northern New Jersey

The State Water Policy Commission of New Jersey, in its first report submitted March 4 to the legislature, finds that a new major water supply for the northern metropolitan district should be available for use by 1940. The so-called district includes the counties of Essex, Hudson, Bergen, Union and parts of Passaic, Somerset and Middlesex.

The development of a high level supply, impounding the upper waters of the north and south branches of the Raritan and the Musconetcong Rivers, is recommended as the next step in an orderly plan for the best use of the waters to be drawn upon for the benefit of the entire district. In the opinion of the commission and its engineers this method is exceedingly important, since it would make it possible to save the heavy cost of pumping to many communities. The consumption of the district in 1928 was about 275 million gallons daily, of which 103 millions were pumped from surface supplies and 50 millions from well supplies.

Residental growth in suburban areas is increasing very rapidly and the above plan would provide for the storage of water at points more remote from thickly settled areas or those which will soon be occupied.

The report points out that the district is now supplied from 34 independent water systems, although some of these systems have interconnecting arrangements that make one available to the other in emergencies. These systems serve a population of 2,800,000. Some of them are privately owned and others are under the control of municipalities.

The commission made but one specific recommendation to the legislature for action at this time. This is a bill providing for a state-wide referendum on a bond issue, the suggested amount being $7,000,000, that would result in lending the credit of the state for the purpose of acquiring major undeveloped sources of supply and the adjacent lands necessary to protect them in all parts of the state.

Montana Water Works Men Meet in April.—The 5th annual meeting of the Montana Section of the American Water Works Association will be held April 17, 18 and 19 at Missoula, Mont. H. B. Foote, Helena, Mont., is secretary.

Sanitary Defects of Ground Water Supplies

Underground Contamination of Supplies—Sanitary Defects Permitting Surface Pollution—Accidental Contamination and Defects in Storage and Distribution

By R. E. LAWRENCE

Assistant Engineer, State Board of Health of Kansas

STATISTICS show that at the present time 50 per cent of the people in Kansas depend upon public supplies as a source of water supply. About 46 per cent of this number are supplied from surface sources, that is water which is obtained from streams or impounding reservoirs. The other 54 per cent are supplied from underground sources. While the number of people receiving water from surface and underground supplies is about evenly divided, statistics further show that 82 per cent of the total number of public water supplies in Kansas are from underground sources. These figures readily indicate the importance of ground water supplies.

The unsatisfactory bacteriological quality of untreated surface water is readily admitted, and in most cases quite adequate works are provided for the purification of these waters. So thoroughly in fact is the purification perfected, that most plants treating surface waters have little difficulty in meeting the rigid standards of quality which are required of treated surface waters. Unfortunately, most people are inclined to place the label of absolute safety on all water from underground sources, and popular belief has it that nothing is more pure than a clear, cold, spring or well supply. Quite contrary to this general belief, bacteriological analyses of the ground water supplies of Kansas over a period of years show a surprising frequency of contamination. Since there is considerable diversity of characteristics as to source of supply, pumpage, storage and distribution, these analyses indicate in a general way the collective sanitary defects of these supplies.

The U. S. P. H. S. Standards, as to bacteriological quality require that:

"(1) Of all the standard (10cc) portions examined, not more than 10 per cent shall show the presence of organisms of the B. coli group.

"(2) Occasionally, three or more of the five equal (10cc) portions constituting a single standard sample may show the presence of B. coli. This shall not be allowable if it occurs in more than—

"(a) Five per cent of the standard samples when twenty or more samples have been examined.

"(b) One standard sample when less than twenty samples have been examined."

What Analysis of Ground Water Supplies Showed.—Using this rigid standard as a basis, an examination of the records of Kansas ground water supplies for the year 1929 indicates that nearly 36 per cent of the supplies met the requirements. Over 25 per cent of the supplies had perfect records for the year, that is, supplies which had a record of analyses for the year without B. coli or B. aerogenes in any sample. An examination of ground water supplies with perfect records for succeeding years shows that 12.1 per cent have perfect records for two years, 6.2 per cent for three years, 4.3 per cent for four years, 3.1 per cent for five years, 2.7 per cent for six years and 1.2 per cent for seven years. Less than 1 per cent of the supplies have perfect records for eight and nine years. These data are of particular interest, since they tend to show that apparently every supply has a first time for showing contamination in samples collected for analysis. These data also indicate that there is need for very careful observation of sanitary conditions of ground water supplies on the part of engineers and public health authorities. The need of very careful protection of supplies from pollution on the part of water superintendents is apparent.

The sanitary defects which permit contamination in supplies either continuously or intermittently may be the result of accident, ignorance or poor design. Unfortunately, however, it frequently happens that contamination reaches the consumer undetected. Generally speaking, sanitary defects permitting contamination in ground water supplies may be classified as follows:

(1) Sanitary defects permitting underground contamination of supplies; (2) Sanitary defects permitting pollution of wells at the surface; (3) Accidental contamination, and defects in storage and distribution.

Defects Permitting Underground Contamination.—The comparatively shallow wells are for the most part subject to the largest variety of faults. Wells less than 30 ft. deep are frequently found to yield contamination, which may be due either to direct percolation carrying bacteria into the ground water stratum, or to holes, tree roots, or other direct ports of entry.

Shallow wells are frequently of the large open dug type, which too often are not provided with a watertight curbing or casing extending deep enough to keep out contaminated surface or very shallow ground water. Casings constructed of brick, porous concrete and vitrified clay pipe are generally unsatisfactory. The gravel wall type of well which is used in sand to increase the yield may be subject to contamination through the gravel unless properly protected. All wells should have a water-tight casing installed to a safe depth or preferably to the water-bearing stratum. Vitrified clay or concrete pipe should have tight joints. In the case of wells using gravel around the casing, the gravel should be replaced with packed clay to a depth of 6 to 12 ft. below the surface, or the dummy casing left in place from the top of the water-bearing stratum to the surface. The safe vertical depth in soil which will effectively filter out surface bacteria varies within wide limits depending on the filtering medium. For solid clay 6 ft. is usually considered a safe depth, and for fine sand, about 12 ft. Through fissured rock or joint clay, there can be no safe distance.

It frequently happens that shallow wells of satisfactory construction show continuous contamination. One city which has come to the writer's attention receives its water supply from shallow wells above an underlying stratum of limestone. The city is unsewered and many of the residences have septic tanks or cesspools. While the wells are located a reasonable distance from such contaminating influences as feed lots, stables, etc., it is quite apparent that this supply can never be satisfactorily without sterilization. Many instances have been noted where abandoned wells and test holes have been the means of polluted surface water reaching the ground water stratum. It is not at all uncommon to find school wells and private wells in small communities being contaminated directly from cesspools.

In the construction of deep wells, failure to extend the outside metal well casing to a sufficient depth and seal into a solid stratum, sometimes permits contaminated surface water or shallow ground water to get into the well. Holes in outside metal casing produced by corrosion quite often permit contamination by allowing seepage into the well. The use of light metal casing as a well tube is hardly dependable. Being subject to corrosion, holes develop more readily to admit seepage, and it becomes weakened to the point of collapse.

Probably the greatest number of sanitary defects in most ground water supplies can be traced to the poor lo-

cation of the supplies, with regard to surface drainage, flooding at times of high water, and proximity to sources of sewage contamination. The only remedy for these conditions is the establishment of the supplies when possible in more favorable locations. Adequate testing before a supply is developed insures not only the best supply available from the standpoint of chemical and bacteriological quality, but also makes possible the best selection of site from the standpoint of sanitary conditions. The comparatively small cost of testing is justifiable in practically all ground water developments.

In the development of springs, the failure to properly curb the springs may result in surface water washing directly into them during rains. Failure to cover the spring boxes or to maintain the overflow level above high water level in adjacent water courses frequently results in springs being flooded by surface water backing up directly into the springs. The use of water from springs with populated watersheds or in limestone formations should not be permitted without sterilization. Water from springs in any formation should be regarded with suspicion until the bacteriological quality of the water under all conditions has been definitely determined.

Defects Permitting Pollution of Wells at the Surface.—Those defects which have to do with the pollution of wells at the surface are for the most part defects of construction, or more particularly improper setting of pumping equipment. The committee report, Conference of State Sanitary Engineers on Development of Ground Water Supplies, which was presented at Cincinnati, O., May, 1924, points out common defects as follows:

"(1) Lack of a tight connection to close the annular opening between the well casing and pump column (sometimes called dropline or suction line).

"(2) Lack of adequate facilities for removing seepage or waste water from a well pit or pump room.

"(3) Connection of well pit or pump room to sewer or drain subject to backflow."

In order to protect well supplies against pollution through the abovementioned defects, the committee has formulated the following: "Suggested Regulations Covering the Installation of Well Pumping Machinery."

"A. Where the pump head is installed without a pit.

"1. The pump head shall be installed on a concrete base of sufficient height to permit the outside casing to extend at least 4 in. above the pump room floor, and to enable the installation of a suitable connection as under A-2.

"2. The annular opening between the outside casing and pump column shall be closed by means of a suitable connection which will effectually prevent waste water, oil or other contaminating material entering the well. Where the pump house floor is below the outside ground level, or is subject to flooding, this connection shall be made watertight.

"B. Where the pump head is installed with a pit or in a pump room below the ground level.

"1. The sides and bottom of the pit or pump room shall be constructed of watertight concrete. It is preferable that the pit be left uncovered, surrounded by a railing, to permit easy inspection by the pump operator.

"2. The annular opening between the outside casing and pump column shall be closed by means of a watertight connection capable of withstanding for 24 hours without leakage, the water pressure resulting from complete filling of the pit with water. The types of connections approved are given below in order of preference.

"a—An all flanged or threaded connection.

"b—A stuffing box connection.

"c—Metal to grouted cement connection with suitable gasket; to be used only when joint carries weight to pump column.

"3. Any vents provided for the well shall be extended by a pipe with screw or flange connections to a point above the floor level. A return ell shall be screwed on the upper end of this pipe.

"d. Drainage shall be provided for the pump pit or pump room by one of the following methods:

"a—By means of a drain consisting of a 6-in. sewer pipe with cemented joints installed in a straight line and on an even grade of not less than 0.6 ft. per 100 ft., with a small concrete bulkhead at the outlet to insure an open discharge at all times; provided that under no conditions shall this drain be connected to a sewer and that the bottom of the pit so drained is above the high water level in any adjacent watercourse.

"b—By means of a pump or ejector drawing from a sump of not less than 5 cu. ft. capacity situated so as to collect all waste water. This pump or ejector should operate automatically or be connected to some moving part of the pump head so as to operate continuously with this pump. This pump shall discharge above the pump room floor level into a suitable drain or on the surface of the ground.

"5. The bottom of the pit or pump room shall be sloped away from the top of the well casing toward the drain or sump with sufficient grade to insure ready flow. At least 6 in. difference in elevation shall be provided between top of the well casing and high water level in the sump."

The committee cites references to typical epidemics caused by pollution of wells at the surface.

In the construction of dug wells, it is common practice to build a platform over the well on which the pumping equipment is set. Too often this platform is not tight enough to protect the well from direct contamination.

Accidental Contamination and Defects in Storage and Distribution.—Many cities with very good groundwater supplies and long records of satisfactory bacteriological analyses, oftentimes find contamination suddenly showing in samples collected for analysis. A careful investigation into the reason for the pollution may show that a pump has been pulled for repair or that repairs or changes have been made in the distribution system. One city in Kansas recently had such an experience, when, after a long period of satisfactory bacteriological analyses, samples were collected and found to contain organisms of the Coli-aerogenes group. This particular supply is obtained from two wells and shortly before the samples were collected meters had been installed for the purpose of measuring the pumpage from each well. Since all of the water pumped passed through the meters, the contamination was scattered generally through the distribution system. It was several weeks before traces of contamination ceased to appear in samples analyzed.

New water mains should not be placed in service until properly sterilized. Specifications covering this point provide for the use of a quantity of chloride of lime in each joint while the line is being laid. New wells can be effectively sterilized by the liberal use of chloride of lime during construction. This is particularly important of wells of the gravel wall type which may become contaminated from the added gravel. It is important that water from new wells be safe before it is turned into the distribution system.

Most states now have regulations governing cross-connections, however, many times old forgotten piping, permits the pollution of a safe supply. All cross-connections not protected in the regulation manner should be eliminated.

The sanitary defects of storage are for the most part confined to surface reservoirs. The use of open reservoirs which hold water for distribution, which is not later sterilized, is particularly undesirable. Such stored water is subject to direct contamination from bird droppings and dust, and algae growth is fostered by exposure to light. Other defects would include leakage which would permit surface water to seep into the reservoir when the water level in the reservoir is low, and overflow connections not properly protected. The remedy for these conditions is obvious. The reservoirs should be of tight construction and covered. Overflow lines should be properly protected by screens or valves.

Where the reservoir area is so large as to make covering impracticable, sterilization is the only alternative.

Conclusion.—Statistics indicate that practically all ground-water supplies are subject to regular, intermittent, or occasional contamination, resulting from definite sanitary defects. Such contamination may be of a serious nature, and may result in a great amount of sickness and loss of life.

The occasional contamination present in many supplies of excellent sanitary aspects is usually the result of accident. This accidental contamination could in most cases be eliminated entirely by the exercise of more care on the part of the operating personnel.

The definite sanitary defects causing intermittent contamination of otherwise safe supplies can in many cases be corrected, and these supplies placed on the safe list.

Where the sanitary defects are such that difficulty is experienced in adequately safeguarding a supply, sterilization is required. Extreme cases of polluted ground-water require complete treatment as with surface supplies.

It is the purpose of public health authorities and water works men to locate and eliminate the sanitary defects causing contamination of ground-water supplies. The failure to permanently eliminate all contamination by the correction of physical defects requires in every case sterilization.

Acknowledgment.—The foregoing is a paper presented Feb. 12 at the 8th annual Three Day School at the University of Kansas and the 5th annual meeting of the Kansas Water Works Association.

Reservoirs Protected by Forestry

Reports of the United States Forest Service indicate that the use of trees for the protection of reservoirs is growing. The city water works department of Akron, O., has developed a transplant nursery in which more than 200,000 seedling trees are growing to a size that will enable them to compete with heavy sod. In Barberton, O., the city water works department began planting on a large scale this year. It is planned, along with the reforesting of idle land, to develop a wide shelter belt of pine or spruce all around the large city reservoir. Such a shelter belt prevents much debris from being carried into the water, in addition to acting as a soil binder.

Paint Hydrants to Mark Pipe Sizes

Different colors of paint are used in Trenton, N. J., to aid firemen in identifying the sizes of fire hydrants. Hydrants attached to 4-in. mains are red, those attached to 6-in. mains are red with orange tops and those reaching mains over 6 in. in diameter are red with green tops.

Damages Awarded for Death from Water-Borne Typhoid Fever

In a decision handed down on Sept. 16, the Indiana Appellate Court affirmed the Judgment awarding damages for a death from typhoid fever. Public Health Records for Nov. 29 contains the following account of the case:

"An action was brought by the administrator of a decedent's estate against the Pennsylvania R. R. Co. and the city of Fort Wayne to recover damages for the death of the decedent from typhoid fever contracted by drinking contaminated water.

"The city of Fort Wayne owned and maintained a water system and furnished water to the inhabitants of the city. The railroad company also owned a water system, taking its water from St. Marys river. In 1903 a connection was made betwen the city's potable water supply and the railroad's supply of river water, a swinging valve and two gate valves being installed to prevent the pollution of the city water by the river water. In the summer of 1923 there were many cases of typhoid fever in a section of the city served by a sewer which emptied into the river upstream from the railroad pumping station. In November, 1923, there were from 135 to 140 cases of typhoid fever in the immediate vicinity of the by-pass and connection between the river water and the city supply, and the plaintiff's decedent was one of the persons afflicted. The city water was used in every infected home in the vicinity of the connection. The plaintiff contended that the death of its decedent was due to the drinking of city water which had become polluted by river water from the railroad main, and alleged that the city and the railroad company were negligent in the maintenance of the connection. A jury trial resulted in a verdict and judgment against both defendants, and on appeal to the appellate court the judgment was affirmed.

"In its opinion the appellate court stated that 'The gate valves on each side of the swinging valve were open, and the jury was justified in finding that the swinging valve would not seat, so as to prevent water from the river flowing into the city water main."

"Further in its opinion, the court also made the following statement:

"It is comonly known that water from a river flowing through cities, towns, and thickly populated country is viewed with suspicion. The circumstances in this case were such that the reasonable probability of the river water being infected should have at all times been apparent to watchful minds, charged with the protection of public health. Both appellants knew, or should have known, that it was unsafe to allow the polluted water from the river to flow into the water mains of the city. The situation was such that the contaminated water in the railroad water main might be likened to a firebrand, and only needed a slight flame to touch it off. A leak in the by-pass was a sufficient flame to start a conflagration. Appellants should have been awake to the situation presented with the gate valve on each side of the by-pass open. They knew that, with these valves open, the only thing which would prevent the river water from being forced into the city main was the swinging check valve, which had never been inspected by either of them after its installation in 1903. As it appears to us, the jury was justified in finding that appellants were, under the facts, negligent in allowing the gate valves to be and remain open, and in not inspecting the check valve, to see that it was seating and serving the purpose for which it was intended."

Results of Cleaning Water Mains

During the past year 4,752 ft. of 8 in. and 5,313 ft. of 6 in. pipe of the distribution system of St. Louis, Mo., were cleaned, the work increasing the efficiency of the mains from an average of 30 per cent to that of 71 per cent. The following note on the work is taken from the annual report for year ending April 8, 1929, of Leonard A. Day, Water Commissioner of St. Louis.

The pipe was cleaned under the supervision of the National Water Main Cleaning Co., which furnished the cleaning equipment and the superintendent. The City Water Division furnished all labor and a foreman. All work was done at night in the downtown section. The total cost was 32-2/3 ct. per foot, including the making of excavation, cleaning the pipe, permanently repairing the street and hauling away the dirt or flushing the street. The improvements effected by cleaning are shown in Table I.

Table I.—Summary of Data on Cleaning of Water Mains in 1928

Location	Size of Main in.	Age Years	Value of "C" Before Cleaning	Value of "C" After Cleaning	Efficiency of Pipe Before Cleaning	Efficiency of Pipe After Cleaning	Diameter of Pipe Before Cleaning in.	Diameter of Pipe After Cleaning in.	Length Cleaned ft.
Clark—3rd to Broadway	6	48	28	93	23.5	77.5	4.5	6.0	675
Morgan—4th to 7th	6	59	32	85.5	26.7	71.0	5.5	5.75	945
St. Charles—7th to 12th	6	47	35	87.5	29.2	73.0	5.56	6.0	1,856
9th—Washington to Locust	6	49	32	81.0	26.7	67.5	5.0	5.75	462
Olive—7th to 12th	6	45	48	84.0	40.0	70.0	5.75	6.0	1,375
6th—Cass to Pine	8	44	44	85.4	36.6	71.0	7.69	8.0	4,752

Note: "C" is co-efficient of roughness as in Williams & Hazen formula.
A "C"=120 was used as a comparison in obtaining the efficiency of the pipe.

Experimental Sewage Treatment Work in Europe

An Interesting Outline of Recent Developments in Various Cities of Germany, France and Great Britain

By G. P. EDWARDS

Principal Assistant Chemist, The Sanitary District of Chicago

A GREAT deal of experimental work on sewage treatment is in progress in Europe, particularly in Germany. New methods are being perfected or old ones modified. New plants are being built which will test some of these new ideas.

In Germany progress is being made in the improvement of the operation and extension of the use of the submerged contact aerators. Activated sludge treatment, using wooden paddles for mechanical agitation in combination with compressed air, is being tried by many cities because of the expected low overall power requirement. The rotation of sludge, in order to speed digestion and to increase the yield of gas, is receiving particular attention. The heating of digesting sludge and the collection of gases are becoming more important, especially for the disposal of the increased amounts of sludge from submerged contact aerators and the activated sludge process. In great Britain a great deal of interesting experimental work is being done on reaeration of activated sludge. The experimental work on different types of activated sludge carried on by the City of Paris will determine the type of activated sludge plant to be constructed there in the near future.

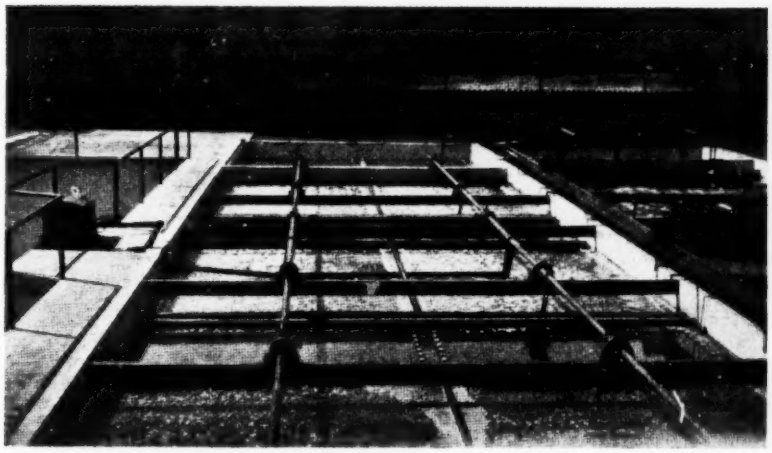


Fig. 2—Stage Operation of Submerged Contact Aerators—Rellinghausen

Germany

Ruhrverband-Rellinghausen.—Some very interesting experiments on stage operation of sewage treatment processes were started early in August, 1929. One series comprises three paddle-wheel aeration tanks, with settling tanks between each aeration unit (Fig. 1). A total aeration period of 2½ hours is being used. The volume of air required is about half the volume of sewage treated (0.07 cu. ft. per gallon). Another series of tanks consists of three stages of submerged contact aerators, with settling tanks between each stage (Fig. 2). A total detention period of 1.5 hours is being tried. The racks, instead of hanging vertically, are fixed on pivots so that they may be suspended at a small angle from the vertical. They are turned from time to time so that either side may be exposed to the air.

Different materials are being tried as contact surfaces in the submerged contact aerators. Pieces of cork 2 or 3 in. in diameter are being used. When in operation the cork is held down by a wire netting. When the wire netting is removed the cork floats and cleans itself. To replace the cork the netting must merely be fastened down. At Iserlohn burlap-covered frames were being installed.

A modified Dorr clarifier under construction will contain a deep sump in the center large enough to permit sludge accumulations of 10 to 11 hours. It is proposed to add ripe sludge intermittently to the sump in order to prevent acid digestion during the storage period.

Hattingen.—An interesting type of grit chamber construction is installed at the Hattingen treatment works (Fig. 3). It is designed to maintain a rate of approximately 1 ft. per second at all flows. As shown in the illustration, the grit chamber is divided into two sections. During dry weather only one section is used, but during storms both parts are thrown into service.

Two stages of submerged contact aerators are being tested. The total detention period is 2.5 hours, which is divided into one .075-hour period for each of the two aerators and one 0.50-hour period for each of the settling tanks.

Mansfeld.—The Mansfeld plant offers an example of the treatment of industrial wastes with the aid of submerged contact aerators and activated sludge. The sewage reaches the plant from two sources in two separate sewers.

About 35 per cent of the total sewage, in one sewer, contains two grams of phenol per liter, introduced in by-products coke wastes. This waste is first settled in an underdrained settling basin for four hours (Fig. 4). The lime and tar settle out. When the beds are full of sludge, they are withdrawn from service, the sludge is dried

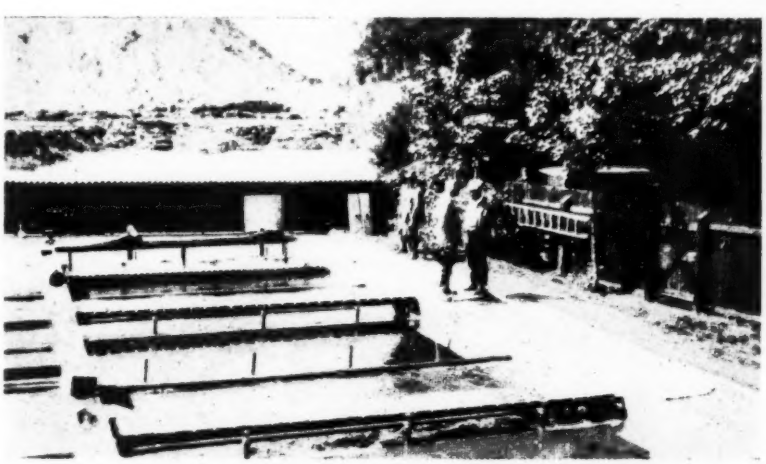


Fig. 1—Stage Operation of Paddle-Wheel Activated Sludge—Rellinghausen

Fig. 3—Grit Chamber—Hattingen

and removed and the basin is again used for settling.

The remaining 65 per cent, in a second sewer, is domestic sewage from 3,000 people. This passes first through an Imhoff tank, which has been in service twenty years. The settled sewage is mixed with the settled phenol waste. The mixture, containing about 700 p.p.m. phenol, is first treated in submerged contact aerators and then in activated sludge tanks. The contact aerators effect a 30 per cent reduction in phenol and the pH is lowered from

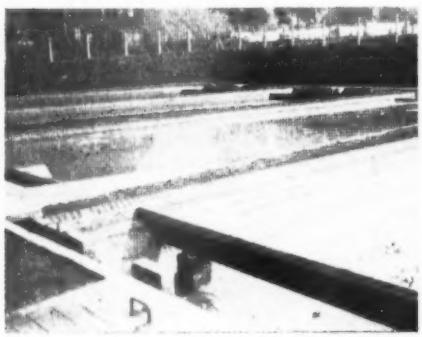


Fig. 4—Underdrained Settling Basins—Mansfiel

8.5 or 9.0 to 2.0. The proportion of air to sewage is about 6.7 to 1 (0.9 cu. ft. per gal.). The proportion of air to sewage in the paddle-wheel activated sludge tank, with a five-hour period, is about 13 to 1 (1.7 cu. ft. per gal.). The effluent contains less than 25 p.p.m. phenol.

Activated sludge without the tauchkörper was used unsuccessfully for a year. Larger amounts of phenol than usual stopped all purifying action in the aeration tanks. The tauchkörper seems to be less sensitive to trade wastes, in general, and especially to sudden variations in amounts of waste.

Iserlohn has the first sewage treatment plant operated solely by power generated by the gases of digestion. No outside source of power is used in the plant. The treatment works consist of Imhoff tanks, submerged contact aerators (Fig. 5) and paddle-wheel activated sludge. Three cubic meters of gas per capita per year (0.29 cu. ft. per capita per day) have been obtained from the Imhoff tanks from the preliminary settled solids alone. An equal amount of gas is expected from the digestion of excess activated sludge and the sludge from the tauchkörper.

Emschergenossenschaft-Essen-Nord.—A new type of settling tank at Essen-Nord seems to show promise of effectively dewatering sludge with a short storage period. An old storm water settling tank has been converted into a preliminary settling tank by installing a deep well in the center (Fig. 6). The sewage enters the tank at the center and flows to the sides. The solids settling in the tank are removed by a mechanical revolving scraper which forces the sludge and scum into slots in the center well. The tank treats about 470,000 gal. per hour. With 20 to 25 minute detention periods, about 75 per cent of the settleable solids are removed. The cost of construction is estimated as being less than the cost of fine screens for a like amount of sewage.

Gelsenkirchen.—An interesting series of experiments on the heating and rotation of sludge has been started at Gelsenkirchen. The sewage received at the treatment works is settled in Imhoff tanks, but since the digestion space is too small for satisfactory operation, six separate sludge digestion tanks, each with a capacity of about 180,000 cu. ft., have been constructed (Fig. 7). The fixed cover is lined with sheet lead 1½ mm. thick in order to prevent gas leaks, and it is insulated by a covering of earth. The tanks are fitted wih apparatus for rotating the sludge. To determine the effect of rotation and of heating, the six tanks are being operated as follows:

1—Sludge rotated, not heated.
2—Sludge quiescent, not heated.
3 and 4—Sludge quiescent, heated.
5 and 6—Sludge rotated, heated.

After digestion for several weeks in the Imhoff tanks, the sludge is pumped to the secondary digestion tanks. Before entering Tanks 3, 4, 5 and 6, the sludge is heated to about 25° C. in heat exchangers. As these tanks are operated under identical conditions in other respects, accurate data should be obtained concerning the advantages and disadvantages of rotating and heating sludge.

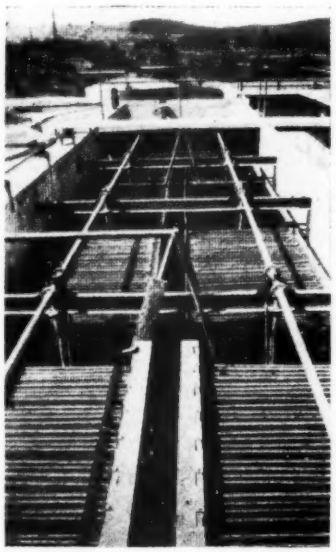


Fig. 5—Submerged Contact Aerators—Iserlohn

Fig. 6—Preliminary Settling Tank—Essen-Nord

Leipzig.—An experimental plant has been constructed at Rosenthal which includes Imhoff tanks, submerged contact aerators and paddle-wheel activated sludge tanks. A sewage flow of about 10,000 to 15,000 gal. per hour is treated. The sewage as received is very strong and septic. The paddle-wheel activated sludge tank requires a portion of air to sewage of 6 to 1 (0.8 cu. ft. per gal.) (Fig. 8). Compressed-air aeration at Leipzig requires a proportion of 10 to 1 (1.3 cu. ft. per gal.). The excess activated sludge and sludge from the tauchkörpers are digested in the Imhoff tanks. Two new tanks are under construction, one for the reaeration of activated sludge and the other for installation of the Haworth process of mechanical aeration. Experimental work at the new treatment works at Wahren has indicated that the use of tauchkörpers before the paddle-wheel activated sludge tanks will reduce the aeration period in the activated sludge from 10 or 12 hours to 4 hours.

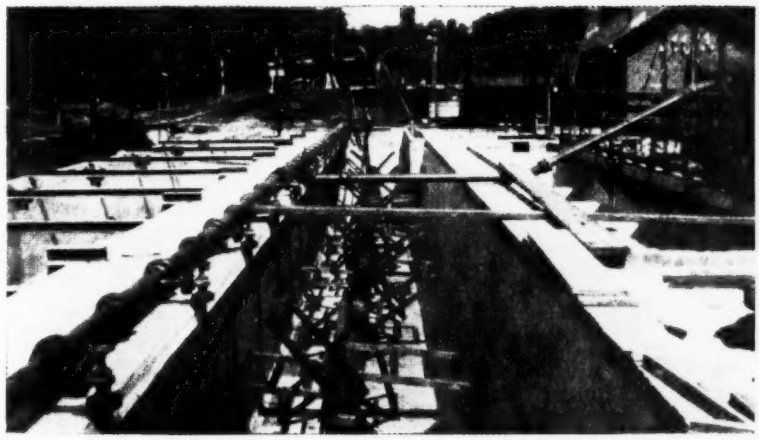
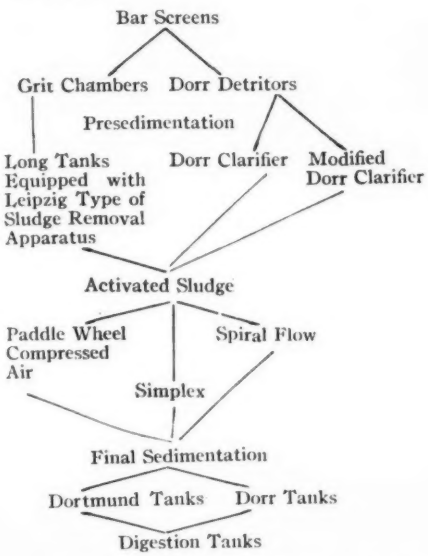


Fig. 8—Paddle-Wheel Aeration Tanks—Leipzig

Berlin.—The Stahnsdorf treatment works now under construction will really be operated on a large-scale experimental basis. The plant, which will have a capacity of about 48 million gallons per 24 hours, will be so arranged that many types of apparatus and treatment can be used. The following diagram shows the proposed arrangement:



All the sewage will pass through the sedimentation tanks, but only about 24 million gallons, or approximately the present dry-weather flow, will be treated by activated sludge. From small-scale operation it was determined that the aeration period should be about 6 hours with 20 per cent returned sludge. About 6 volumes of air to one volume of sewage (0.8 cu. ft. per gal.) will be necessary. Twenty aeration tanks 70 ft. wide, 230 ft. long and 13 ft. deep are being built.

The excess activated sludge and preliminary sludge will be digested three days to dewater it before it will be pumped to the final digestion tank. It will pass through heat exchangers similar to those being used at Gelsenkirchen, in which it will be heated to 21° to 23° C. before entering the final digestion tanks. There it will be digested about three months. Sludge rotation according to the Prüss scheme will be used in some of the tanks. Gas will be collected and used for power.

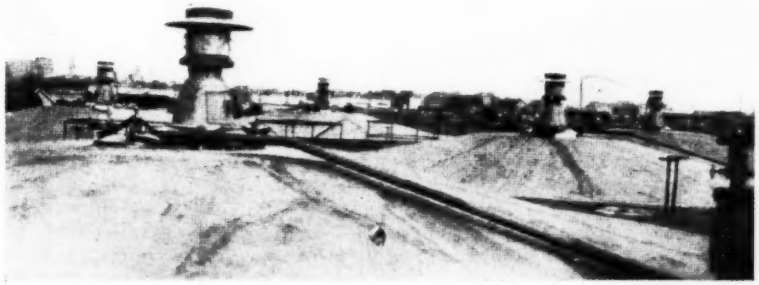


Fig. 7—Separate Sludge Digestion Tanks Fittel with Sludge Rotation Apparatus—Gelsenkirchen

Small-scale sludge digestion experiments with the Prüss sludge rotation scheme have been carried on for nine months. According to the data, the sludge has digested more rapidly and 20 to 30 per cent more gas has been obtained than without rotation. The gas contained about 18 to 20 per cent more carbon dioxide than was found in the gas from the non-rotated sludge.

France

Paris.—The experimental station at Colombes has investigated three sys-

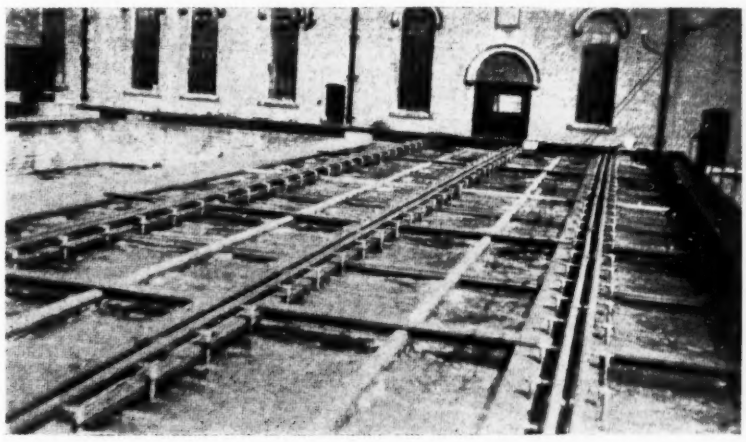


Fig. 9—Experimental Activated Sludge Plant—Glasgow

tems of activated sludge: simplex, diffused air and the Lamy process. The latter scheme consists of a tank with a vertical down-well, which reaches nearly to the bottom of the tank. The sewage, returned sludge and air are added at the top of the trapped down-well, flow out of the bottom and rise to the surface. No data on operation were available.

Great Britain

Sheffield.—Haworth is trying one of his aeration units on a fill-and-draw basis to eliminate the necessity of using nine small hopper-bottom settling tanks for one aeration unit. The main objection to fill-and-draw schemes is the time necessary for filling and drawing. In general practice, Haworth empties a tank in 45 minutes without disturbing the settled sludge. The tank is 3 ft. deep and has a flat bottom, except for a 7-ft. sump at one end. The tank is filled with sewage and the required amount of sludge and the contents are circulated for the customary period. The paddles are shut off, the sludge allowed to settle one-half hour, and the clear supernatant liquor and the excess activated sludge are drawn off from the deep end of the tank. An automatic device gradually lowers the level of the drain. The tank is then refilled and the paddles started. The operation of drawing is almost entirely automatic and requires a minimum of labor. Since the tanks had been in operation only a few weeks, no data were available.

Glasgow.—At Shieldhall an experimental spiral-flow activated sludge tank, which has been made from an old settling tank, treats about 300,000 gal. per day (Fig. 9). The sewage requires 1 cu. ft. of air per gallon with an aeration period of 6¼ hours. Re-aeration of sludge had been used for some time successfully, but during the summer it was discontinued. In a short time poor results were noted and re-aeration was resumed.

Birmingham.—Important work on short-period aeration of settled sewage before treatment on sprinkling filters is showing very good results. The capacity of the filters is being increased about twice. A new aeration unit to treat 12,000,000 U. S. gallons per day, which is about one-third of the total settled sewage received at Minworth, is about to go into operation. The new tanks will be of the diffused-air type with a 60 deg. sloping bottom on both sides of a row of porous plates. Pre-aeration of the settled sewage before addition of the activated sludge will be tried. The sewage with the activated sludge will be aerated one hour. The sludge will be re-aerated four or five hours.

Interesting work is also being carried on at Manchester, but time did not permit a visit to this city.

Acknowledgment. The foregoing is reprinted from the January Sewage Works Journal, the official publication of the Federation of Sewage Works Association.

Liability of City for Act of Health Officer

An interesting decision on the above subject was handed down Oct. 29, 1929, by the Supreme Court of the State of Ohio in the case of the City of Salem vs. Harding (169 IV. E. 457). Public Health Report for Feb. 7 comments as follows:

The city of Salem owned its public water system, the water being pumped from deep wells and conducted to a central reservoir. The water from one group of wells was conducted to the reservoir by means of a gravity line constructed of vitrified pipe with cemented joints. Not many feet from this gravity line and running parallel thereto was a sewer constructed of clay pipe without cemented joints. Property owners had been ordered to disconnect from this sewer, but such orders were apparently not complied with by everyone. Thereupon the city health officer, in conjunction with an employee of the service department of the city, plugged the outlet of the sewer. It was claimed that this caused the sewage to back up until the pressure was such that the sewage filtered through the intervening soil into the gravity water supply line.

The plaintiff in the trial court brought action against the city to recover damages because of typhoid fever contracted by his daughter as a result of the impure water supply, his action being grounded upon a claim that the city had been negligent. A verdict in favor of the city was rendered in the trial court, but on appeal to the court of appeals the judgment was reversed on the sole ground that the trial court had erroneously charged the jury as follows: That, even though the jury should find that the gravity line was contaminated by the plugging of the sewer, thereby forcing pollution into said gravity line, the verdict must nevertheless be for the defendant if the plugging was done by and under the instructions of the board of health or health officers of the city, and also that no action could be maintained or recovery had against the city based upon any acts of negligence either of commission or omission of its board of health or health officers.

The city appealed and the supreme court affirmed the judgment of the court of appeals. After citing another case to the effect that, while the construction and institution of a sewer system was a governmental matter, the operation and upkeep of sewers was a proprietary function, the supreme court said: "Still adhering to the proposition that the construction and institution of a sewer system is a governmental function, we are nevertheless of the opinion that the city is liable for any obstruction thereto, which is known to the city, if the city through its proper officers knew or in the exercise of ordinary care should have known that the obstruction would have an injurious effect upon life or property. The city being responsible for its negligence upon the foregoing principles and authorities, it may not escape that responsibility on the sole ground that it was acting in the exercise of its police power."

Another point determined was that the city was not a guarantor of the purity and wholesomeness of its water supply.

Compressed Air Cleans Concrete Forms

A useful device for cleaning out forms before pouring concrete was employed in the construction of the new Lambton Mills bridge on the outskirts of Toronto, Ont. A ¾-in. pipe was flattened somewhat at one end and attached to a rubber hose, which was connected up with a source of compressed air. An air line was brought along the deck of the bridge from the compressor and tapped at intervals. Just before pouring concrete, the air was turned on and the end of the pipe pushed down between the reinforcing bars, with the result that chips of wood and other forms of rubbish were blown to one end where they could be removed.

Salaries of County Officials.—The County Bureau of Efficiency of Los Angeles County, California, has published a "Survey of Salaries" wherein amounts paid positions in county service are compared with those for similar positions in 155 private concerns of that city. It was found that out of 83 categories compared, the county paid more than private employers in 55 classifications and less in 28. On the whole, it was concluded that public employment does not suffer in comparison with service in private concerns in that municipality.

Green Concrete and Sea Water

Special precautions are taken by the Delaware, Lackawanna & Western R. R. in protecting green concrete which is to be exposed to sea water. If possible, the water is kept from the concrete for 30 days. The concrete is mixed extra rich and rather dry, the amount of water being kept to 5 gal. per bag of cement. It is recommended that all concrete exposed to sea water be given an asphaltic protective coating.

Pipe Protectors for Fire Hydrants

Fire hydrants in New York City are protected by pieces of steel or cast-iron pipe filled with concrete. Pipe from 6 to 8 in. in diameter is used, and it is placed with about three feet in the ground and enough projecting above to protect the hydrant. A pipe protector is placed on each side of a hydrant likely to be hit by motorists.

Experiences of a Filter Plant Trouble Shooter

Preparation of Water for Filtration—The Jar Test—Red Water Troubles—The Odor and Taste Problem—How Air Binding Was Eliminated—Maintenance of Filter Beds

By L. E. WICKERSHAM

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PRESENT-DAY practice in water purification has become simplified materially over that of years past, to a large extent through the efforts of those scientifically engaged in the design of filter plants, in the production of improved filter appurtences and mechanical equipment for more accurate control of chemical feed, and in the study, experiments and research work done on various problems which have confronted those engaged in this art.

The trend of time, the same as in other fields, requires water works to be efficiently supervised and operated in order that the finished water be of high standard and above reproach. Many of the water supplies, heretofore furnished, were not satisfactory from a chemical standpoint, and in numerous instances, bacterially unsafe for domestic use. Criticism on the quality of the water whether it be as to taste, odor or color, imaginary or otherwise, is more quickly expressed, and greater care is being exercised by the water company and the municipality to guard against such criticisms, which may have far-reaching and harmful effects on controlling interests.

It is thus needless to say that the development in the purification of water has passed beyond the stage where it can be entirely entrusted with safety to operators with but superficial training, and lacking sufficient education and interest to understand and reason. Not only are numerous periodicals, papers and articles written on the treatment of water, but meetings like this, for the discussion of problems confronting the operator, are held by many of the states, fostered generally by the State Department of Health.

Few Plants Free From Problems.—Even with the advance made in the treatment of water, there are comparatively few plants that are not confronted at times with some complexing problem, whether the water is derived from an acid laden stream, an upland impounded or underground supply. Irrespective of whether it is taste or odor from microscopic organisms, mineral constituents or organic matter, formations, decaying vegetable matter or color derived from certain geologic or industrial wastes, or whether due to operation, such as air-binding of the filters or imperfect filtration, the operator or chemist in charge must be able to ferret out without delay the cause and be able to remedy the same. There are cases where problems unexpectedly arise, not heretofore experienced, and it is found that correction cannot always be had by some particular treatment found successful at other plants. Different waters usually require different preparation and treatment.

Preparation of Water Important.—Much of the trouble generally experienced in operation is due to the lack of knowledge by operators in satisfactorily preparing the water for filtration. Success of any plant depends a great deal on the arrangement and efficient operation of settling basins. The elements of time, temperature, hydrogen-ion concentration and agitation are determining factors in the effective coagulation and settling of water. The period which is required to bring about the proper degree of coagulation varies with different waters, and authorities claim that this is caused, aside from those elements just mentioned, by the kind and amount of salts in solution, the character of suspended colloids, and by the amount of chemicals applied. Complete flocculation may take place in from 10 to 20 minutes, while with some waters, it may not be effected at the end of four hours. This especially may be true of waters low in alkalinity and turbidity. It is customary to refer to the time of settling as the period corresponding to the duration of flow or displacement of water in the basin, however, such a period generally is not obtainable, and the water passes through in considerably less time.

Velocities are affected by baffling, temperature and air conditions. After a proper coagulating of the water has taken place, the water must be subjected to as little agitation as possible, as a state of quiescence is necessary to bring about the greatest degree of deposition of settleable matter. When the turbidity is high, the chemical dosage should be so apportioned that the greatest reduction of suspended matter possible is obtainable in the basin, the aim being to effect the most economical and efficient coordination between basin and filters. An attempt should be made to remove enough of the suspended matter, so that, in the applied water, the turbidity does not exceed 75 parts per million, better still 25 to 35 parts per million.

The Jar Test.—Where a water is found difficult to coagulate, or to remove color, preliminary experiments by means of the "jar test" should be made to determine the amount of chemicals necessary for the efficient treatment of the water, and the time required for satisfactory coagulation and subsidence. Although this is familiar to many, it possibly may be new and useful to others. Prepare a stock solution of alum, lime or soda ash, whichever used, by adding 1.714 grammes of the chemical to 200 cubic centimeters of distilled water, so that 1 cubic centimeter of the solution applied to 500 cubic centimeters of the sample in a white glass cylinder or bottle is equivalent to 1 grain of the coagulant or alkali added. Thoroughly agitate by a general stirring, and note the time and character of floc formed, as well as period for subsidence of the coagulated and suspended matter. A series of these tests will indicate the minimum dose of chemicals necessary.

Valuable information also can be had, and used at most plants to successful advantage in the preparation of the water, by knowing the optimum point of coagulation as determined by the hydrogen-ion concentration. Having once determined the optimum pH, it is merely necessary to collect samples of the water from the mixing chamber and determine its pH. This may range anywhere from 4.5 to 7.5, but usually is in the neighborhood of 6.9. In the case where sulphate of iron is used in conjunction with hydrate of lime, it usually will be found necessary to carry the pH value considerably higher, in order to produce a good coagulation and maintain a water free of corrosive action.

Where artificial alkalinity is being employed, extreme care must be taken, especially with some waters, to avoid the settling of organic color or the production of a milky effluent, by the use of too large an amount of lime. Provided color is a factor, and it is necessary owing to a low alkalinity and relatively high CO_2 content to use an alkali, hydrated lime is more satisfactory than the use of soda ash.

Red Water Troubles.—Should red water troubles be caused by too high a free CO_2 in the final water, experience has shown that it should not be completely absorbed by increasing the alkali in the settled water, but rather by aeration or reduction in the clear water basin. In a number of our plants where lime is used, we endeavor to carry a slight amount of free CO_2 in the applied water, and to produce a phenolphthalein alkalinity of from 0.5 to 2 parts per million in the final water by secondary treatment with an alkali in the clear water basin.

In some of our plants in the past, trouble has been experienced in properly clarifying the water due to the limited capacity of the settling basins, especially where the turbidity was exceedingly high and considerable sediment had accumulated. Where these conditions have occurred we have found it advisable to install a blow-out system in order that the mud and sediment can be syphoned out from all parts of the basin without putting it out of service. The operation does not involve any additional operating expense except the slight cost of the coagulant wasted with the flushed water.

The question of coagulation and its theory is very comprehensive and one with which most plant operators encounter more or less trouble but I have attempted in a general way to cover certain phases of this important feature of plant operation.

The Order and Taste Problem.—Another problem, equally as vexatious, is that of odors and tastes, and the clogging of the filter media due to certain forms of misroscopic organisms. Many of these organisms bring about rapid chemical changes in the water by exhausting the CO_2 content and reducing the bicarbonate alkalinity to normal carbonate alkalinity, as well as causing the water to become supersaturated with oxygen. Plant operators usually know from experience just about when these organisms put in an appearance and the time to start treatment to prevent their growth.

Where algae are present in large amounts, whether alive or dead, and reach the filters, the loss of head will build up rapidly and cause short filter runs. Combined with this, generally, is air-binding, which, until corrective measures are instituted, necessitates a short wash of about a minute to break the vaccum in the filter and liberate the air.

How Air Binding Was Eliminated.—A recent occurrence at one of our New Jersey plants demonstrates this clearly. The supply, which is derived from an impounded reservoir of some 170-million gallons capacity, is piped a distance of several miles, and thence lifted to a new 3-million gallon sedimentation basin. About a week prior to placing the basin in operation, the water, then being lifted directly to the filters, gave evidence of containing considerable algae. We had experienced this growth in the past, and for some years had treated the water successfully with chlorine as it entered an improved settling basin constructed at the lower end of the impounding reservoir. However, this year the algae appeared several weeks earlier than heretofore and before prechlorination had been started. The filters soon became clogged, necessitating from 40 to 60 washes a day. After washing, a run of from 60 to 80 minutes was had before the filters would again become air-bound, necessitating a breaking up of the media by means of a short wash. A microscopic examination of the water showed a number of forms of algae, the most numerous, and also one of the most troublesome in clogging filters, being the synedra of the diatoms. In addition to the chlorine applied at the impounding reservoir, a secondary treatment was given the water as it entered the settling basin.

Although the water was comparatively clear, and under normal conditions would have needed not over one-half grain of alumn for satisfactory coagulation, it was increased fourfold or about 2 grains per gallon in order to more rapidly settle out the organisms and prevent their being carried over onto the filters. With a heavy "floc" thus formed, the filters were then given a long wash and put back in service at a considerably slower rate. Within a day after this treatment, and change in method of filter operation, air troubles had been eliminated. The least amount of air getting into the under-drain system by way of leaky valves or controllers when the filters are operating under vacuum, tends to be liberated and to be entrapped in the voids in the filter media and results in air-binding. It is for this reason that an inspection of such filter appurtenances should be made periodically and remedial measures taken. It is also found at times that considerable air reaches the water through the raw water and wash water pumping units and chemical feed lines.

We have also found with algae growth in a sedimentation basin, where, due to the lack of turbidity in the water, it was somewhat difficult to get a heavy enough floc to carry down the organisms, that desired results could be had by the introduction of artificial turbidity by applying a solution of clay to the raw water. Fire clay, which precipitates readily with alum, can be applied either in suspension or fed through a dry feed machine.

The operators of plants which are troubled with algae or other similar microscopic organisms should be continuously on the lookout for these organisms during the season of growth, and should include in their laboratory control, a microscopic examination of the water, otherwise the first indication he may have of an increase in these plankton will be filter trouble, or increased color, taste, or odors in the water. The libraries of such plants by all means should contain a copy of Whipple's book on "The Microscopy of Drinking Water."

Maintenance of Filter Beds.—It is needless to say that extreme care must be taken in the maintenance of the filter beds, but how many of the operators actually do draw down the water every week or so in order to make an inspection of the sand. Once mud balls start to form, they are hard to eliminate, and unless taken care of their penetration becomes deeper, necessitating the removal of the sand and its cleaning or renewal. Mud ball formation is not due to the quality of the sand, but is caused by inefficient coagulation, or by an imperfect wash resulting from the failure of the washing system to expel and carry away the accumulation of mud lifted out of the bed by the wash water, or to a combination of both. Cracks in the sand indicate penetration of mud into the sand due, generally, to insufficient wash, while a crater of sand denotes a broken strainer or air line.

There are instances of both the over and under washing of filters. In the case of the former there is a chance, providing it is necessary to put the filter back into service under maximum rate, of carrying fine turbidity or coloring matter through the filter until after a "mat" has formed, thus reducing the bacterial efficiency of the unit. In the case of under washing, mud ball formation is bound to occur. The filters can be kept in better condition with less wash water and provide for a more uniform bacterial reduction by stopping the wash when there is evidence of clearing in the wash water. One cannot too often call attention to the inadvisability of rapidly opening either the wash water or effluent valves. This practice often is the cause of loosening the strainers, the blowing out of the sand, or the breaking through of the surface with the production of inferior water.

There are many other troubles which the filter plant operator experiences from time to time, but it is impossible to cover them all in a paper of this nature. In concluding let me say that every water purification plant should be operated under careful supervision and laboratory control. Do not wait until forseen trouble arises before measures are adopted to correct it. Be two steps ahead and prevent its occurrence. No matter what type or design of plant you have, it must be properly maintained and well operated to insure satisfactory results. No water company or municipality may with security ignore the necessity of producing at all times a pure and potable water supply.

Acknowledgment.—The foregoing is a paper presented at the last annual meeting of the Pennsylvania Water Works Operators' Association.

Meeting of New England Sewage Works Association.—The Spring Meeting of the New England Sewage Works Association will be held in conjunction with the meeting of the New England Health Institute, April 15 and 16, 1930, at the Hotel Statler in Boston.

The Water Cycle Between the Ocean, Atmosphere and Land

A General Survey of Some of the Outstanding Points in the Sciences of Physical Oceanography and Meteorology Showing Their Relation to Practical Problems of Water Supply

By GEO. F. McEWEN

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The program of the water supply section of the school of citizenship and public administration in the Short Course last year at the University of Southern California was arranged to give the broadest and most fundamental treatment of the subject of water supply. Inclusion of "Oceanography" in the program is a specific illustration of the attitude which accords with the generally accepted principle that applied science, hydraulic engineering, for example, is based upon investigations in pure science in which scientific curiosity, or the understanding of nature, is the incentive. In his paper, which is reprinted below, Professor McEwen discussed the science of physical oceanography and the closely related one of meteorology with the purpose of showing their relation to practical problems of water supply.

BEFORE considering the water cycle, I shall define briefly the words ocean and oceanography. The word ocean denotes that great connected sheet of water which covers the earth's surface. Oceanography is the science that would deal exhaustively with the ocean, and is therefore a large part of the essentially composite science of geography, whose subject matter is, for convenience, classified with reference to the three geospheres, the atmosphere, the lithosphere and finally the hydrosphere, which includes all of the water, both on the ocean's surface and in the atmosphere. The ocean is therefore less than the hydrosphere.

Physical oceanography is essentially a composite science, and as applied to the ocean waters includes, first, the accurate measurement, throughout the ocean, of the physical and chemical properties of the water, such as its temperature, motion, salinity, gas content and acidity, and second, the precise formulation of problems suggested by these data and the corresponding meteorological and astronomical data, with the purpose of coordinating and interpreting this objective information and thereby discovering the corresponding laws of these phenomena.

Occurrence and Average Distribution of Water.—First consider briefly the occurrence and distribution of water in the sea, the atmosphere, over the earth's surface, and within the geological strata. Some idea of the amount of water in the ocean is suggested by the fact that the salt if separated from the water would form a layer of nearly 50 yd. deep over the whole surface of the earth. The volume of water in the sea is eleven times that of all land above sea level and is approximately three hundred and twenty-seven million cubic miles or one eight-hundredth that of the earth. While water occurs mainly in the ocean it permeates the atmosphere in the form of vapor, clouds and fog. In addition to its visible occurrence in lakes and reservoirs, large amounts are distributed throughout the soil even down to a depth of thousands of feet in some regions. Using the volume of water in the ocean as a convenient unit a general idea of the average amount of water distributed in these various ways is presented by the following table:

Volume of water in the ocean	1.00
Volume of water in the soil (ground water)	0.005
Volume of water in all inland seas and lakes	0.00009
Volume of water in the atmosphere	0.000009

While the estimates give an idea of the average distribution of water the condition is not static. From exposed water and land surfaces water continually evaporates into the air, where it exists in the form of vapor, and is carried in accordance with the atmospheric circulation to be condensed into fogs or clouds, from which a part is precipitated as rain or snow. After precipitation a large proportion returns to the original source, the ocean thus completing the water cycle of transformation and transportation.

Transportation of Water Vapor from Ocean to Land.—In considering some of the details of the different processes that constitute the water cycle I shall begin with the atmosphere and deal mainly with the North Pacific region. Averaging many thousand observations of wind and barometric pressures indicates a "high" pressure area about a thousand miles west of San Francisco and a "low" pressure area over the Aleutian region. Winds blow out spirally from the "high" in a clockwise direction and blow in spirally toward the "low" in a counterclockwise direction. The "high" moves northward and farther from the coast in summer. It also increases in intensity and area and the prevailing winds become steadier and stronger. The "low" is especially well developed in winter and disappears in summer. South of the equator the winds are counterclockwise about a "low" and clockwise about a "high." A chart of the winds indicates a line of "convergence" (a line toward which air flows from both sides usually accompanied by a flow parallel to the line) between the "high" and "low" directed toward Vancouver in the winter and Central Alaska in summer. An equatorial line of convergence in the doldrum region is equally prominent. This is between the two oppositely circulating whirls about the "highs" of the North and South Pacific. The whole system is subject to a seasonal shift of several hundred miles to the north in summer and the south in winter of the northern hemisphere. Along both the North and South Pacific coasts of America is a large cold water area between the "high" and the coast and extending toward the equator. These areas are especially cold and extensive when the "highs" and their accompanying winds reach their greatest development.

Certain outstanding characteristics of the precipitation of the coastal region will now be considered in relation to these atmospheric and oceanic conditions. As a general rule on-shore winds are accompanied by precipitation, while off-shore winds are dry. Polar winds are dry, and winds blowing from lower latitudes into higher bring much moisture. Lines of "convergence" have abundant rainfall.

The Pacific Coast State of Colombia, South America, has rain at all seasons and is in the doldrum line of convergence. Farther northwards, along the coast from Panama to Guatemala, about 90 per cent of the precipitation falls during the six months from May to October. The northern Mexican frontier located in the off-shore trade-wind region is practically arid throughout the year, and north of this region extending as far as Vancouver Island the winter is the rainy season, corresponding to the changes in the "high"

and "low." The coasts of British Columbia and Southern Alaska have much rain throughout the year but most falls in winter when the frequency of cyclonic storms is greatest.

In addition to these regular seasonal variations there are differences from year to year. Occasionally very great departures occur and can be explained by corresponding changes in the ocean. A striking example of direct ocean influence upon coastal weather is afforded by the westward deflection of the Humboldt current in 1925, which permitted the warm equatorial waters to penetrate southwards along the coast of South America. This unusual development of the warm counter current, El Nino, resulted in abnormally heavy rains along the arid coasts of Ecuador, Peru and Chile. At the same time there was a corresponding deviation of the cold Benguela current, thus permitting the warm waters of the Guinea current to penetrate southward along the west coast of Africa where torrential rains resulted along that arid coast. There is some evidence of a recurrence of a similar phenomenon about every thirty-five years.

Conditions Essential to Precipitation.—On the average there are about five parts of water vapor per thousand parts of air by weight, and the higher the temperature the greater is the possible amount of water vapor. This invisible vapor when cooled sufficiently condenses, forming fogs or clouds. Minute particles, ions, dust, etc., which are widely distributed throughout the atmosphere, act as nuclei which greatly facilitate this condensation. The densest clouds contain about five grams of water per cubic meter of air. An average amount would be near one gram of water per cubic meter of air or about one part in a thousand by weight. The individual water particles are about 0.03 mm. in diameter. Further cooling is necessary to produce precipitation, the drops of water being as much as two or three millimeters in diameter. Accordingly, conditions essential to precipitation are primarily conditions that cool the atmosphere, which is a mixture of air and water vapor. This cooling may be brought about by mixture with relatively cold air, by a flow towards regions of higher latitude where a relatively lower temperature prevails, or by rising and expanding as the pressure decreases. In the atmosphere the latter process of "adiabitic expansion" is by far the most important cooling agency, producing clouds and precipitation. Accordingly, it is important to study the conditions that cause a rapid rise of air.

Orographic and Cyclonic Rain, and the Polar Front Theory of Storms.—A very good example of certain rain producing conditions is afforded by the warm, moist ocean winds blowing to the northwest from the Indian Ocean and turning to the northeast across the Arabian Sea and the Bay of Bengal during the northern summer. Wherever these monsoon winds, which have passed over a warm ocean path some 4,000 miles in length and are saturated with moisture at a relatively high temperature, are directed against steep slopes of coastal mountain chains in India there is heavy precipitation called orographic because of the topographic factor. The air is deflected upward along these slopes with sufficient velocity to produce a rapid fall in temperature. Where the winds descend over the warm land surface the air takes up any available moisture and precipitation is impossible.

If the air current is stable (density decreases at a greater than average rate as the height increases), as it is forced up a slope the surrounding air is lighter and thus ascent is resisted. The air will tend to flow out around obstacles rather than to continue upward. This explains why oftentimes the heaviest precipitation does not occur at the top of a mountain but at some intermediate elevation. Air warmed from below, as often happens in winter, when the air is colder than the sea, is unstable, and orographic rainfall is thereby aided. On the other hand, when air is cooled from below, as is often the case in summer over the cold inshore water belt of our California coast, a local fog or slight drizzle results, but orographic rain is hindered.

A different but very important condition producing a rapid updraft of air independently of local topography often develops at a surface of discontinuity, separating warm and cold air at the same level. By means of a very close network of stations in Norway, Professor Bjerknes found that warm winds converging toward colder winds rise above the colder air and their moisture is condensed in the same way as in the air rising up mountain slopes. There is convincing evidence that polar and equatorial air meet at a surface of discontinuity which intersects the surface of the earth and sea in a wavy-line extending entirely around the earth at about 50 deg. north latitude but departing hundreds of miles on either side of this average position. "Highs" and "lows" result from the separation of loops forming in this line of discontinuity or "polar front."

The weather of the northern hemisphere is a consequence of advances and retreats of this polar front which marks the frontier between masses of air of different origin. The expulsion of great masses of polar air, forming anti-cyclones, is an essential element in the general circulation. Warm air flows along the surface of the earth and sea from the subtropic "highs" toward the polar regions, concentrating in warm tongues and continuing into the polar regions at the upper levels where it cools and later reaches the lower levels. Thus masses of cooled air accumulate behind the polar front and cause it to advance southward. Finally, at places of least resistance great masses of cold air break through and are expelled in the direction of the tropics. This results in a northward retreat in the polar front, after which the process is repeated. Moreover, this intermittent quality of the general atmospheric circulation is especially characteristic of the winter season when marked discontinuities of sea surface temperatures prevail.

A succession of cyclonic storms then develops from alteration of the polar front, and they travel from west to east along tracks which appear as lines of convergence in charts of monthly averages. The structure of one of these cyclones is essentially as follows. There is a warm sector of less than a quarter of the total area and lying to the south, this air flows in a counter clockwise direction and is deflected upward over the cold air at the right (the observer is assumed to be facing to the north). The cold air also flows in a counter clockwise direction and forces the warm air upward at the left of the warm sector. Both of the boundaries of the warm sector are lines of convergence. According to hydrodynamic theory a line of convergence will move to the right of an observer looking along the line in the direction of flow. Thus there is an ascent of air at both of these lines and the cyclone moves from west to east. The spiral motion is due to the combined effect of the low pressure of the central area and the deflecting force due to the earth's rotation. There is in general an interchange of warm and cold air causing a transformation of potential into kinetic energy. Both the irregular and seasonal north and south displacement of the polar front result in a corresponding migration of the storm tracks, and the position and intensity of the North Pacific "high" determines how far south these cyclonic storms reach the North American coast. Finally, the sea temperatures due to the influence of latitude, evaporation, and the varying ocean currents are a fundamental control of the "highs." Thus we are led to regard the ocean and overlying atmosphere as parts of a complex mechanism driven by the sun's energy and obeying the laws of physics.

The Return Flow of Water from Land to Sea.—Precipitation varies greatly with respect to geographic location and with respect to time. It may be in the form of rain or snow. A combination of such a variety with a corresponding variety of topography, nature of soil, and growth of vegetation results in a great diversity of run-off. A part of the water collects in lakes or artificial reservoirs, some penetrates into the earth's surface, forming ground water, some is evaporated, and some flows directly into the sea. All of these conditions raise important problems in water supply engineering. I wish to emphasize the importance of

preserving a suitable vegetation cover to prevent erosion, which results in loss of arable soil and silting of storage reservoirs.

Owing to the interconnection of the oceans and the oceanic circulation the run-off becomes distributed over the whole surface of the sea. Thus we are led to consider the process of evaporation which completes the water cycle.

Evaporation from Water and Land Surfaces.—Although complementary to precipitation and of equal importance there is much less quantitative information about the rate of evaporation. This is due to the fact that while the measurement of precipitation is direct and readily made, evaporation must be determined indirectly from suitably made observations. For example, direct observations from a pan must be corrected by special methods in order to obtain the evaporation from a neighboring lake or reservoir. Although many investigators have worked on the problem of determining the rate of evaporation from lakes and reservoirs, owing to inherent difficulties and to lack of time to carry out a thorough rational investigation of suitable technic, discordant results have been reached. Empirical methods were used and there was neither general agreement as to the relation of pan evaporation to that of a large body of water nor as to the method of estimating it from meteorological data. Even less satisfactory information has been obtained about ocean evaporation, owing not only to certain observational difficulties not met with on land, but also to lack of a rational method of their interpretation. Available observations indicate a rate of about 2.7 ft. per year from the sea. There is also evaporation from the soil which under different conditions varies from about 20 per cent to 9 per cent of that from a water surface.

About ten years ago at the Scripps Institution, while working on problems of circulation and temperature distribution, I was handicapped by this meagre knowledge of ocean evaporation. The available results of evaporation investigations were either purely empirical and therefore of only local value, or theoretical but involving simplifying assumptions departing so widely from actual conditions in nature that the general conclusions could not be accepted. Even combinations of existing theoretical and empirical methods that proved very helpful in certain local engineering problems of water supply lacked the desired quality of being generally applicable.

In spite of the need of a clear understanding of the physics of evaporation long recognized by engineers, geologists, meteorologists and oceanographers, no investigation of the subject, leading to satisfactory results, had been carried out up to that time. Mr. Cummings, then assistant in physical oceanography at the Scripps Institution, undertook at my suggestion to make a critical study of the problem of evaporation. This investigation begun at the Scripps Institution led to cooperative work at the California Institute of Technology a few years later by Messrs. Cummings, Bowen, Richardson and Montgomery, to whom I am indebted for material which I have condensed into the following summary.

It is natural to regard evaporation from lakes as a process controlled by atmospheric conditions, such as air temperature, wind, and humidity. This view, then shared by Dr. Cummings, was not supported by an extensive statistical analysis which he made for the purpose of isolating the effects of various factors influencing evaporation. In particular, a very weak correlation was indicated between evaporation and humidity. He concluded that there must be a fundamental physical reason for this unexpected result.

The Water Softening Plant of Miami, Fla.

Accordingly, it was decided to make a new beginning and attack the evaporation problem from the standpoint of the first law of thermodynamics. This investigation led him to formulate the following qualitative principle of evaporation analogous to the principle of Chatilier, in physical chemistry, and Lentz's law in electricity and magnetism. Any change in wind or humidity is always accompanied by a change in lake temperature which partially neutralizes the direct effect on the evaporation rate to be expected from the original change in atmospheric conditions, if the insolation remains constant.

The evaporation rate must evidently be determined entirely by energy, rendered available for that purpose in accordance with the equation

$$E=\frac{I-B-S-K-C}{L} \quad \ldots\ldots (1)$$

where (E) is the evaporation rate expressed in centimeters of depth, (I) is the incoming radiation per cm² of surface, (B) the back radiation to the sky, (S) the heat consumed in warming the water (or heat storage), (K) a correction due to heat transferred to or from the air as sensible heat, (C) a combined correction for leakage through the walls of the container, expansion of the water, and heat carried by flowing water. All quantities in the numerator are expressed in gram calories per square centimeter of open water surface and integrated over the time interval corresponding to (E). Let (R) be the ratio of sensible heat carried away by the wind and diffusing into the air to the latent heat carried off by the vapor. Then

$$LER=K \quad \ldots\ldots (2)$$

The ratio (R), although generally regarded as small, is not negligible, but available information was crude and limited. Thus the approximate equation used by Cummings to estimate evaporation from lakes,

$$E=\frac{I-B-S-C}{L(1+R)} \quad \ldots\ldots (5)$$

where (R) was neglected, suggested the need of a critical investigation of its value.

A theoretical attempt to relate the value of (R) to easily measurable quantities, and thus make possible an accurate estimate of evaporation from equation (5) was very successfully carried out by I. S. Bowen at the California Institute of Technology. His results, presented under the title "The Ratio of Heat Losses by Conduction and by Evaporation from any Water Surface," were published in the Physical Review, June, 1926, pages 779-787. For simplicity Bowen at first assumes diffusion coefficients, conductivities, and densities to be independent of temperature.

Then

$$m=D_1a(P_1-P_2)/L \quad \ldots\ldots (1)$$

is the mass of water vapor diffusing per unit time across a space of length (L), and area (a), where (P_1) and (P_2)

are the densities of water vapor at the two faces of the space, and (D_1) is the diffusion coefficient of water vapor through the air. Multiplying both sides of equation (1) by the latent heat of vaporization (L), and denoting the energy per unit volume in the form of latent heat by (θ_1) and (θ_2), the energy (Q_L) carried across becomes

$$Q_L = D_1 a(\theta_1 - \theta_2)/L \quad \ldots\ldots (3)$$

The formula for that energy (Q_s) carried, by conduction, across the same space is

$$Q_s = Ca(T_1 - T_2)/L \quad \ldots\ldots (4)$$

where (C) is the conductivity of the air, and (T_1) and (T_2) are the temperatures of the two faces. But $C = D_2 C_p d$ where (D_2) is the "diffusion coefficient" or diffusivity for the heat energy, (C_p) is the specific heat at constant pressure, and (d) is the density of the air. Therefore the substitution of this value of (C) in (4) results in the equation

$$Q_s = D_2 a(Q_1 - Q_2)/L \quad \ldots\ldots (6)$$

where $Q_1 = T_1 C_p d$ and $Q_2 = T_2 C_p d$ are respectively the densities of specific heat energy at the two faces. The equations (3) and (6) for the transfer of latent and sensible heat respectively, are of the same form, and from kinetic theory (D_1) is only a few per cent greater than (D_2). Accordingly, heat losses by evaporation and diffusion, and conduction should follow the same laws and be affected in the same way by convection.

Suppose first, that the wind velocity has a constant value from the surface to a small height, (b), above the lake surface. If the lake is large and the velocity and height (b) are small, the layer of air from (O) to (b) will have its temperature changed to that of the water and will become saturated with water vapor. That is, its specific heat density will change from (Q_2) (value at windward side) to (Q_1), (value at water surface), and similarly its latent heat density will change from (θ_2) to (θ_1).

Therefore

$$R = \frac{Q_1 - Q_2}{\theta_1 - \theta_2} \quad \ldots\ldots (9)$$

since this is the ratio of the two kinds of energy taken on by each cubic centimeter of the air passing over the lake.

Next suppose there is no wind between the lake surface and the height (b). If the area of the lake is small and the velocity large, the water vapor and heat diffusing through the stationary layer from the lake surface to the height (b) will be carried away immediately and we can assume ($Q = Q_2$) and ($\theta = \theta_2$) at the layer at height (b). Under these conditions the rates at which heat and water vapor leave the water surface are determined solely by diffusion, and their ratio, found by dividing equation (6) by (3) is

$$R = \left(\frac{D_2}{D_1}\right)\left(\frac{Q_1 - Q_2}{\theta_1 - \theta_2}\right) \quad \ldots\ldots (10)$$

Case I represents a condition where the whole quantity of air under consideration is completely changed in temperature and moisture content to that of the layer of air in contact with the water. For this reason diffusion is not the limiting factor and hence the diffusion coefficients do not enter into the formula for the ratio of the heats lost by the two processes. It is obvious, however, that if conditions are such that diffusion does enter, it will be in such a way as to increase the loss by the process having the larger diffusion coefficient relative to the loss by the other method. Hence under any conditions of wind we may say, since $D_1 > D_2$ that

$$R \leq (Q_1 - Q_2)/(\theta_1 - \theta_2) \quad \ldots\ldots (15)$$

Case II, on the other hand, represents conditions where diffusion is the completely determining factor, the heat and water vapor being immediately carried away after diffusing through the stationary layer. If, however, these are not immediately carried away, they tend to build up the temperature and vapor density on the upper side of this layer, and thus decrease the gradient in the stationary layer. This in turn tends to slow down further diffusion. But the process with the larger diffusion coefficient will build up faster, and hence will be retarded more than the one with the lower diffusion coefficient. Hence we can write

$$R \geq D_2(Q_1 - Q_2)/D_1(\theta_1 - \theta_2) \quad \ldots\ldots (16)$$

Also, a pair of differential equations derived from the basic assumptions, and valid for all points above a lake, was solved, assuming the wind velocity to be proportional to any positive power (n) of the distance above the surface. This led to the result

$$R = \frac{Q_s}{Q_L} = \left(\frac{D_2}{D_1}\right)^{\frac{n+1}{n+2}} \left(\frac{Q_1 - Q_2}{\theta_1 - \theta_2}\right) \quad \ldots\ldots (14)$$

Making use of well known relations of (D_1), (C_1), and (P) to temperature, Bowen found that equations (9) and (10) reduced respectively to

$$R = .501 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (22)$$

and

$$R = .442 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (23)$$

which he replaced by

$$R = .46 \left(\frac{T_w - T_a}{P_w - P_a}\right) \frac{P}{760} \quad \ldots\ldots (24)$$

since the general solution indicates that, under ordinary conditions the value of (R) is nearer to that given by equation (23) than by equation (22).

T_a = temperature of the air.
T_w = temperature of the water.
P = pressure of the air in mm.
P_a = the partial pressure of water vapor in mm.
P_w = the partial pressure of water vapor if the air were saturated and had the temperature of the water surface.

Bowen's theory, relating (R) to readily measurable quantities, thus provides the information needed to render Cumming's equation (5) exact. However, the importance of being able to estimate (R) renders independent tests of Bowen's theory highly desirable, in order to establish its validity and discover its limitations. Cummings and Richardson undertook to test the theory by experiments involving the comparison between a small insulated evaporating pan and large tanks.

Empirical estimates of lake evaporation based upon pan observations are subject to error since water in pans of different sizes is known to evaporate at different rates. There was no general agreement as to the proper method of reducing pan evaporation to lake evaporation.

Solving equation (5) for (I — B) results in

$$H = I - B = S + LE(1+R) + C \quad \ldots\ldots (4')$$

where (H) is called the heat budget per square centimeter of surface. (I) must be the same for all water surfaces exposed to the same external conditions, but (B) varies with the surface temperature, and is therefore in general different for different bodies of water. Using subscripts (1) and (2) for the pan and the other body of water respectively, and remembering the equality of (I_1) and (I_2) results in the equation

$$B_1 - B_2 + S_1 + LE_1(1+R_1) + C_1 = S_2 + LE_2(1+R_2) + C_2 \quad \ldots\ldots (5')$$

The difference in temperature found between the two water surfaces being less than 15° C. in his experiments, Stefan's law of black body radiation gives ($T_1 - T_2$) (.5) as the value of ($B_1 - B_2$) in calories per sq. cm, per hour. Therefore since all quantities in equation (5) can be directly measured it can serve to test Bowen's theory under any desired conditions. Moreover, if the theory is correct, and the evaporation (E_2) from one body, a lake for example, can not be measured equation (5') can be used to compute it. Cummings and Richardson have published the results of their experimental tests of equation (5') under the title "Evaporation from Lakes" in the Physical Review for October, 1927, pages 527-534.

The dimensions of the containers used as as follows:

	Pan	Tank at Pasadena	Tank at Fort Collins
Area	0.37	2.2	520. sq. m.
Depth of vessel	.19	1.47	2.0 m.
Depth of water below rim	.01	.02	.07

The tank at Fort Collins was so large that insulation was unnecessary. Both of the other containers were insulated and corrections were made for

the small leakage. Many comparative runs were made under quite dissimilar circumstances. A remarkably close agreement was found between the two members of equation (5′), thus proving Bowen's method of determining (R) to be a high precision under field conditions. Therefore the evaporation from a lake can be computed by determining (H_1) from pan observations near the lake and applying the ($B_1 - B$) correction for estimating (H), the heat budget of the lake and substituting in the equation

$$E = \frac{(H - S - C)}{L(1 + R)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

where (S), (R), and (C) are determined for the lake.

This research is more than a comparison of evaporation from two containers of different dimensions, since if any technique is ever developed for measuring (H), then lake evaporation can be found without using a pan or measuring wind velocity. The procedure outlined can be used to measure lake evaporation with satisfactory precision, and reliability, and although like most primary standards it is difficult to apply it should aid in developing methods more readily applicable in case great accuracy is not required.

Evidently it is important to make many field tests of the value of (R) under dissimiliar conditions, and thus provide general information regarding the probable value of this correction.

This procedure measures by means of a pan, the amount of energy available for dissipation by the larger body of water in the items of evaporation convection and sensible heat, but does not enable the absolute amount of energy reaching the water surface to be computed. Only the back radiation difference between the pan and tank has thus been considered. A later detailed consideration by Richardson and Montgomery of the radiation-exchange between the water and the atmosphere indicated that the effective radiation from a water-surface could be accurately represented by the equation

$$B = aT_w^4 - baT_a^4$$

where (T_w) and (T_a) are respectively the absolute temperatures of the water and the air above it, (b) is a factor (approximately = 0.9) which corrects for the fact that the atmosphere does not radiate as a perfectly black body. Accordingly, the incoming radiation from the sun and sky per square centimeter of surface, corrected for reflection, can be computed from pan observations from the equation

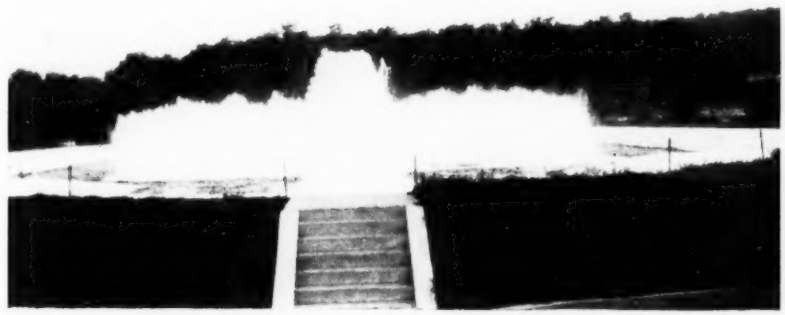
$$I = S + LE(1 + R) + B + C$$

Comparisons of values of (I) computed from this equation with pyrheliometer readings indicated a departure of but 4 per cent. Accordingly, the evaporation from an exposed body of water computed from the equation

$$E = \left\{ I - aT_w^4 + baT_a^4 \right\} \div L(1 + R)$$

will be subjected to a small relative error of about 4 per cent where either pan or pyrheliometric observations are used for estimating the available solar and sky radiation denoted by (I).

During the progress of these investigations which, except for observations of the total amount of heat in the



The Influent Aerator at the Water Filtration Plant of Providence, R. I.

body of water, were concerned with conditions in the air above the water surface, I was attacking the problem from a different angle. However, all of the work was based upon energy changes. My results are presented in a Scripps Institution technical bulletin being printed by the University of California Press, under the title:

A Mathematical Theory of the Vertical Distribution of Temperature and Salinity in Water under the Action of Radiation, Conduction, Evaporation, and Mixing Due to the Resulting Convection: Derivation of a General Theory, and Illustrative Numerical Applications to a Tank, a Lake, and a Region of the North Pacific Ocean.

The following brief statement is based upon this publication. Oceanic circulation involving a general flow either vertical or horizontal causes corresponding changes in the distribution of temperature and salinity. For example, investigations of the California coastal region indicated marked changes of this kind. In attempting to work out quantitative relations between circulation and the accompanying temperature changes it was found necessary to determine the "normal" distribution of temperature and salinity. That is, it became necessary to develop a physical theory of the absorption of solar radiation, back radiation from the surface, conduction of heat through the air, heat loss due to surface evaporation and the transfer of heat and other properties of the water by the alternating motion of water, especially from one level to another.

This general problem pertains not only to the ocean but to all exposed bodies of water. My treatment of it assumes that the time rate of change of temperature at any given level in a lake may be regarded as an effect of four groups of causes.

First, heat is added by the absorption of solar radiation, a process which can be neglected except at depths within the region extending only a few meters below the surface.

Second, heat is transferred within the lake from one level to another, by means of eddy motion or turbulence in a manner agreeing, formally with the law of heat conduction in solids.

Third, because of winds or horizontal gradients of specific gravity there may be a general drift or flow of the water, resulting in an accompanying transfer of heat.

Fourth, heat is removed from the water surface by evaporation, back radiation and conduction through the air. The resulting increase of specific gravity of a thin surface layer of the water causes a settling of relatively heavy and cool masses of surface water, compensated by a rise of relatively warm and lighter water.

All but the fourth group of causes have been extensively investigated, and a theory of this diffusion of surface heat loss downward can be developed as follows:

Assume that surface water masses tend to remain at that level, and consequently do not descend unless adequate forces are present. General experience relative to the variability of conditions in open bodies of water such as lakes, suggests that at different positions on the surface the forces required to cause the water masses to descend will be different. Accordingly, in the absence of detailed knowledge a normal frequency distribution of density departures is assumed, and the rate of settling of each small water mass at any level is assumed to be

proportional to the difference between its specific gravity and that of the surrounding water. Thus water masses whose specific gravity and corresponding temperature vary through a certain range fall to different levels, and the surrounding water rises. Furthermore continuity of mass requires an equality of upward and downward flow at each level.

Using this basis the problem was formulated by attempting to devise a mechanism whose behavior could be worked out mathematically. By a process of fitting the resulting equations to observations of temperature and salinity from the surface to a depth not exceeding 100 meters even in the ocean, and repeated at regular time intervals, the physical constants can be computed corresponding to each time interval. These computations furnish theoretical estimates of the rate at which solar radiation penetrates the surface, the rate of surface cooling. Thus by applying the Bowen ratio and back radiation correction used by Cummings and Richardson, an estimate of evaporation is provided without the use of the pan. Furthermore, by applying the same mechanism of downward diffusion to the distribution of salinity and combining the resulting equations with those pertaining to temperature a method has been worked out for estimating separately the surface cooling due to evaporation and to other causes. This method is independent of all observations except serial temperatures and salinities and is theoretically adequate for estimating evaporation from the ocean.

While a good deal of information has been obtained regarding the water cycle there are many deficiencies as to detail and there is room for much progress in theoretical studies carried on for the purpose of understanding the physical laws and interpreting the observations. Moreover, we have the fundamental instrumental designs and theoretical technic for making quantitative estimates of the elements composing the water cycle, but there is need of applying them to an extent commensurate with the importance of this vital world-wide phenomenon.

New Jersey Proposes $7,000,000 Bond Issue for Water Supply Protection.—A bill has been introduced in the State Legislature of New Jersey providing for the issuance of $7,000,000 of bonds by the state for the protection of potable waters. To become effective under provisions of the constitution, the measure would have to be ratified by the voters. If passed, the referendum would be a part of the November election. The purpose of the bill is to provide for costs of acquiring lands, water rights and other interests for the protection of potable waters in the state.

Boom Activities in Engineering Construction Predicted

The outlook for construction activity in 1930 is gradually taking definite shape, according to E. J. Harding, assistant general manager of the Associated General Contractors of America. "Our statistical data now indicates boom activities in highway, public improvement and all other classes of engineering construction," he states. "The first indication of an acceleration of building activity is now at hand and relates to non-residential construction. Prospects for residential work are still indefinite with no specific indications of revival yet at hand."

The favorable outlook for engineering construction is based on several indicators, according to Mr. Harding. The increased sale of state and municipal bond issues during December, 1929, and January, 1930, presents a combined total for such bond sales that has been exceeded but once by any similar combined total.

A further indicator is seen in the recent increase in federal aid appropriations for state highways, which increase of $50,000,000 annually should result, when matched with state money, in an increase of more than $100,000,000 for such work during 1930.

Reports on contemplated work as compiled by the F. W. Dodge Corporation show that engineering construction on the boards between Jan. 1 and Feb. 7 is 188 per cent greater in valuation than during the same period in 1929. These figures relate to projects being planned by engineers which have not reached the contract award stage.

Engineering construction contract awards for this year up to Feb. 7 show an increase over last year of 60 per cent. This is seen by the contractors' association as a tribute to the manner in which federal, state and local governmental agencies have expedited plans for construction in response to President Hoover's appeal after the stock market decline.

The first indication of an acceleration in private building operations is now visible in the reports of contemplated work in the non-residential field up to Feb. 7. These are 30 per cent greater in valuation than similar reports in 1929 and are seen as a very hopeful augury for the future.

A. W. W. A. Membership Campaign Off to Good Start

Five hundred new members before the St. Louis convention is the ambitious goal set by Arthur E. Gorman, chairman of the 1930 membership committee of the American Water Works Association.

The campaign in its first stage was launched three weeks ago with an appeals to the entire membership of A. W. W. A. for assistance in furnishing a list of "live" prospects. The returns were most encouraging and indicate a wide interest in the campaign by the members. To date 257 cards have been returned to the committee recommending 2,009 prospects for membership.

The drive is being organized in cooperation with the section offices and committees in the unorganized states. The following table shows the quota set by the membership committee and the prospect returns received to date:

Section	Quota	Prospects to Date	Ratio P/Q
California	25	121	4.7
Canada	30	142	4.7
Central States	40	241	6.0
Florida	15	35	2.3
Four States	55	143	2.6
Illinois	25	113	4.5
Indiana	20	26	1.3
Kentucky-Tennessee	20	62	3.1
Minnesota	12	33	2.8
Missouri Valley	30	142	4.7
Montana	6	33	5.5
New York	55	295	5.4
North Carolina	20	79	4.0
Pacific Northwest	15	26	1.7
Rocky Mountain	20	45	2.3
Southeastern	30	106	3.5
Wisconsin	10	82	8.2
Non-Organized States			
Foreign	5	19	4.0
Louisiana	5	25	5.0
Nevada	2	17	8.5
New England	25	106	4.2
Southwest (Texas, Oklahoma, Arkansas)	25	88	3.5
Virginia	10	30	3.0
Total	500	2,009	4.0

The campaign will be carried out along two major lines:

1. Personal solicitation.
2. Direct mail.

The direct mail campaign to prospects will consist of five mailings beginning the third week of March and concluding two weeks before the St. Louis convention. Through section committees it is planned to personally solicit every prospect on the list, the direct mail campaign being depended on to create interest in the association and assist in the membership drive.

Enthusiasm is running high at headquarters and among the various section and state committees everyone interested in A. W. W. A. is being called on to make this campaign a success State sanitary engineers, manufacturers' representatives, water works superintendents, consulting engineers, in fact everyone contacted with so far by the membership committee has agreed to assist in putting the drive over the top.

Every month a summary of the results of the drive will be published. Watch for results and put your shoulder to the wheel for 500 new members before the convention meets in St. Louis.

"Water Works Accounting and the Public"

An Outline of the Common, Everyday Problems of the Water Works Superintendent, and Notes on the Practice at Raton, N. Mex.

By G. C. CULBERSON

Manager, City Water Works of Raton, N. Mex.

IT is easy for water works men to become self-satisfied with their plants; to get into a rut, so to speak; satisfied with everything about us and just drifting with the tide. Now, the reason that I come to this convention from year to year is to gain knowledge that I do not have of the water business and then to go back home and put some of it into pratcice, consequently improving our water system. I do not consider that my board makes a better investment during the year than the money expended for my expenses to this convention.

Accounting Systems.—There are many systems of general accounting in the water business; and some are worse than others. It is difficult, of course, to fit any one accounting system to every project, some plants being privately owned and some municipally owned. But for all purposes I think the Uniform Classification of Accounts, as prescribed by the National Association of Railway and Utility Commissioners, comes nearer meeting the needs of the average plant than any I have seen. And remember, too, there are still many that I have not seen. That system is capable of being expanded to meet the needs of the larger plants. I think it has less "bunk" and superfluous stuff in it than any I know of.

I have no "ax to grind" for any accounting system in particular, but I am fearful that many of us do not know where we are; and what I want to say is that we should know absolutely, as we are entitled to. Do you know if your plant is self-sustaining? Is it making money or losing money? These are vitally important questions for our consideration.

If your plant is a municipally-owned one, it is a separate entity and does it have a distinct and a separate set of books of account? Too often the case is that the water business is dumped in with all of the other activities of the city and consequently nobody knows what it's all about. That, in my opinion, is altogether wrong. As manager or superintendent you are entitled to know. If everthing in the way of revenue is in one pot how are we to know if our rate structure is too low or too high. Mr. Tax-Payer may be the goat for such blunders; he generally is. If you have dog tax and paving tax and water revenue all thrown in together it is utterly impossible to analyze your costs with any degree of accuracy. Let us insist that we have a separate set of accounts so that we may know if our efforts over a given period have been properly and profitably directed. Of course, if you have a privately-owned plant, this phase of this paper is of no interest to you.

Audits.—Another general proposition is the accounting end of our work. Do you have an annual or semi-annual audit? I think this is one of the best topics we water men can take. It is not only good for water men but it is good for any kind of business. We might have become ever so proficient as managers and superintendents, and the employes we have under us might be ever so capable, but an audit will clarify the atmosphere between your department and the public. And in many cases it will reveal errors that have been expensive. Sometimes we might be charging into operating expense items that properly belong in our capital accounts. Or we might be charging off as uncollectible bills too many accounts that should have been collected. And so on. There are numerous defects that an audit will bring to the surface.

Some will say, "well, an audit costs too much money." All things being equal I think it brings greater returns than any money expended. The influence of an audit is beneficial, even if no errors are found and no money recovered; the fact that all concerned know that an audit will be made periodically is worth more than the dollars and cents value.

Some will say, "well, I don't think we need an audit." In the majority of cases that is the fellow that needs an audit. Sometimes we dislike the idea of having a doctor with us because we are afraid he will tell us what is wrong with us. That is the time we need the doctor, and so it goes with the audit.

You may say this has no bearing on the accounting subject. Yes it has. Periodical audits will be helpful in getting modern methods installed and things properly systematized. Let us have audits in the water business. It seems to me that it helps somewhat to dignify the business we are in, and puts it on a higher plane.

The Raton Plan.—In developing some further points I want to refer to the way we do some things down at Raton, N. Mex. However, I hope you will not get the impression that we think our plant is beyond improvement. We have plenty of room for improvement; that is one reason I am here at this convention—in quest of new ideas and practices.

Our plant is municipally owned. Our population is about 7,000, and we have 1,630 water taps. Our taps are 99 per cent metered. It is a gravity system, the impounding reservoirs being some 10 miles from the city.

A board, created some years ago by city ordinance, known as the Board of Public Works, administers the affairs of our water department. Four men constitute this board, two from each of the major political parties. (We have only two brands of politics down there, republicans and democrats.) These men are appointed for terms of four years each, one term expiring each year. (Our city elections are every two years.) Board managers draw $100 per year salary. The board appoints a manager and he has charge of operations. The board meets one time every month and more if necessary. Monthly reports are made to the city, and a copy of the annual audit goes to it at the end of the fiscal year.

Sinking Fund.—Our bond issue is being retired annually from a sinking fund created by a tax levy. There is room for argument and discussion at this point. Our laws in New Mexico make this an optional point. We can retire bonds either with water revenue or tax money. My personal opinion is that perhaps the better plan is to retire bonds with water revenue. This is the only place where there is any interlocking of the accounting system as between the city proper and the water department.

The question I raise is this: Do you have a bond issue and are you putting money from any source into a sinking fund with which to retire the bonds. This is an important question. If you answer in the affirmative, well and good. If not, let me urge you to make such provision within a reasonable time after date of issue.

Reserve.—Every water plant should have a reserve, and not simply a book proposition, but a cash reserve or the equivalent thereof. The character of the water business with the emergencies that arise at flood periods often calling for an outlay of capital, demands that available funds should be provided. Such funds will be created only if your rate structure is at the proper level and cost of operations properly supervised.

It is advisable to invest such funds in approved securities and allow inter-

est therefrom to go back into and build up the reserve.

As to the extent of such a cash reserve, or how much money should be accumulated in it, is difficult to say, as a rule. But I should think not less than from 7 to 10 per cent of the value of the fixed assets. When such an amount has been reserved good business judgment will dictate as to the lowering of rates.

Another important advantage in having a comfortable cash reserve is that it precludes the necessity of having to issue bonds every time any improvement or replacement of assets is to be made. Bond issues are fine for the bond houses and the brokers but they are extremely expensive on the taxpayers. Let us insist on building up a cash reserve, if we have not already started one.

The Public.—Getting down to the consumer: Our consumers' ledger is a loose leaf affair, with space for four years business on it; also, space for the tap number, address of owner and his name, name of tenant, lot, block, and addition description. We have found these to be very satisfactory.

There is, of course, a general ledger control account into which the value of the consumers ledger must tie. These are balanced with the control every month, in our office. Not semi-annually or quarterly, but monthly.

We deal with property owners, only, or their agents, and not with tenants as such. We have found this rule very satisfactory. If a property owner lives in California and wants a local man to be his agent we furnish him with a form of a contract, designating so and so as his agent. But the property owner is still responsible for water bills.

Under New Mexico laws liens may be filed for water bills; in other words the property stands for the bill. We do not resort to that law except in extreme cases.

Quarterly or Monthly Billing.—We bill the consumer quarterly. (More room for argument.) Briefly, we bill quarterly for the reason that it precludes the necessity for making out bills and reading meters twelve times each year as against four times. At the same time I appreciate the fact that a consumer will pay monthly, or small water bills, with more grace than he will a larger, or quarterly one. Some consumers say they prefer the quarterly bills so that one trip to the office to pay suffices for three months, and there you have it—take your choice. However, I believe in the majority of cases bills are rendered monthly.

Discount on Water Bills.—One of the most progressive steps taken in our department for years was the adoption some two years ago of a discount of 10 per cent, on water bills, if paid within 15 days after the end of the quarter. It has cured more ills than any one rule we have. The folks like it. We now have it in both the water office and the light office.

We had people, just as you have them, that we were forever and eternally hounding to pay their water bills. Not so now—and those were good people in our city; good citizens. I say it has created harmony and good feeling. It is a loud speaker for good will.

Good Will of the Public.—All of this naturally leads into a discussion of good will, one of the most invaluable assets: the good will of the consumer—it amounts to much. We should cultivate it. We as managers are to blame in no little degree for the attitude of the public toward our business.

People are the same the world over. They rebel at one thing, one lever, that we water men have. That of chopping of the water when the bill is not paid. An advantage which I think should be exercised with common sense and judgment. And it is so easy to just tell a consumer "Take it or leave it"—we'll cut your water off if you get fresh with us. That sort of an attitude toward the public will not only destroy any good will there might be but will utterly fail to get the confidence of the public. Courtesy at the counter or window will go far toward creating and cultivating good will. A smile at the proper time is a good stimulus. A little time and patience with a consumer in trouble helps wonderfully. We should not forget that the average consumer knows almost nothing about what to do when something goes wrong with the water pipes and fixtures. Naturally, the first place he thinks to call up is the water office. That is the logical thing to do. Let us enjoy the confidence of the people and their good will just as other businesses do. We have the remedy in our own hands.

Big Water Bills.—What do you do when a consumer comes in with a water bill all out of proportions that he's "all het up" about—scared to death that he is going to be compelled to pay it. The meter has charged him up with enough water to start a good sized river. At this point is a good time to display some tact and common sense—the two words are synonymous. A little sympathy and patience will calm the consumer greatly, if he is a normal human being.

We, under such circumstances, go and make an investigation of his case—check up pipes and fixtures on his premises. If we find that he has a leak of which he knew nothing about, from some underground source, we simply propose to him that we will cut his bill in half (50 per cent reduction) on the condition that he have repairs made immediately and stop the waste of water. He, in the majority of cases, is delighted over the idea of not having to pay all of the bill, and settles it then and there, and goes out feeling like he got a square deal after all.

In checking up large bills care should be exercised, of course, and if he has had leaky faucets or fixtures of any kind common sense will tell you that the family had known of the leak; and in such a case there is only one thing to do—demand that the bill in full be paid.

In reading meters we have a plan whereby we pick up large readings and inform consumers either by phone or otherwise at once. They appreciate it. It is good psychology, too, because when time of settling the bill comes it is easier to get along with them.

Beautify Consumer's Premises.—Another thing that will promote good will and good feeling is to take part in contests to have the best kept lawn, flower garden, and shrubbery. It is remarkable how much a little paint, some water, fertilizer, and grass and flowers, will improve appearances of property. Affiliate with the local civic clubs and foster such a contest and let the water department offer one of the substantial prizes.

When we do such things we not only help the consumer but we help to beautify the city, property values are enhanced, and if the system is metered, all of the prize money and more will come back to us through revenue.

Acknowledgment.—The above is an abstract of a paper presented at the last annual meeting of the Rocky Mountain Section of the American Water Works Association.

Expense Ratios and Costs of Water Sold.—The following table taken from the 16th annual report (1928-1929) of the Pasadena, Calif., Water Department, S. B. Morris, Superintendent and Chief Engineer, shows the expense ratios and costs of water sold for the above period:

	Percentage of Water Revenues	Percentage of Total Expense	Cost of Water per 100 cu. ft. (in cents)
Source of water supply	4.05	2.28	0.35
Pumping expense	22.62	12.71	1.98
Purification expense	.34	.19	0.03
Water production	27.01	15.18	2.36
Distribution expense	8.88	4.99	.78
Commercial expense	9.43	5.30	0.82
General	12.52	7.03	1.09
Operation and maintenance	57.84	32.50	5.05
Depreciation	31.48	17.69	2.75
Interest	10.68	5.99	.93
Total	100.00	56.18	8.73

Water production total, 638,954,400 cu. ft.
Total water sales, 567,039,700 cu. ft.
Cost of water per 100 cu. ft., based on water sold.

Illinois Section A. W. W. A. to Meet at Chicago.—The annual meeting of the Illinois Section of the American Water Works Association will be held at the Stevens Hotel in Chicago, April 23-24, 1930. J. J. Doland, 317 Engineering Hall, Urbana, Ill., is secretary.

A Recent Development in Lime Water Softening

Improved Process Provides for Addition of Calcium Carbonate on Sludge Produced from Water Softening Reactions

By CHARLES P. HOOVER

Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio

THIS process or development relates to a method of reducing carbonate hardness of water by lime softening to the theoretical or approximately to the theoretical limit, that is to the solubility limit or approximately to the solubility limit of calcium carbonate and magnesium hydroxide. The process comprises adding to the water sufficient lime (CaO or $Ca(OH)_2$) to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium hydroxide. Considerable lime (25 to 50 parts per million) in excess of that theoretically required to replace the magnesium must be added in order to convert the magnesium salts in the water to magnesium hydroxide. This leaves excess lime or caustic alkalinity ($CA(OH)_2$) in the water. After partial settling the excess lime is neutralized with carbon-dioxide, then calcium carbonate, water softening sludge or other inert finely divided material is intimately mixed with the water after which it is clarified by settling or filtration.

What Water Softening Reactions Show.—Water softening reactions, as usually written, indicate and show that when hard water, containing bicarbonates of calcium and compounds of magnesium, is treated with lime for softening purposes, the highly soluble bicarbonate is converted to insoluble or only slightly soluble normal carbonate and that the magnesium is converted to magnesium hydroxide which is only slightly soluble.

Unfortunately, lime water softening reactions do not proceed in cold water or water at ordinary temperatures in an orderly fashion as represented by chemical equations. The precipitates of calcium carbonate and magnesium hydroxide are produced in a state or condition in which it is impossible to remove them by ordinary processes. Until very recently a 50 per cent average reduction of magnesium and an average reduction of carbonate hardness to 50 or 60 parts per million was considered as being as good as could be obtained. Many results running as high as 85 or 90 parts per million are recorded. During the first twenty years that the Columbus, O., plant was in operation, the alkalinity or carbonate hardness was reduced to an average of 50 parts per million, whereas theoretically it should have been reduced to some place between 15 and 20 parts per million.

Policy at the Columbus Plant.—Chemical handbooks usually record the solubility of calcium carbonate as being 13 to 20 parts per million and magnesium hydroxide as being 1 part per million, or in terms of calcium carbonate, 1.7 parts per million. These figures therefore represent the theoretical limit to which carbonate hardness can be reduced by lime softening. At the Columbus plant it has been the policy of the water department most of the time since the plant was started, to reduce the total hardness to about 85 parts per million or to 5 grains per gallon. Had the improved process, described in this paper, been available and been used during the past 20 years at Columbus, there would have been a saving of something more than $400,000 in the operating costs of the plant because more hardness would have been removed by lime and less with soda-ash, which is a more expensive softening chemical. Details showing how the $400,000 saving would have been made are given in the 1929 report of the Columbus Department of Water; they are reported by Chemist in Charge.

Data on Operation of Columbus Plant.—At this point it might be of interest to digress for a moment and show in tabular form some of the pertinent data regarding the 21 years of operation of the Columbus plant. These figures are taken from the 1929 water report and were prepared by Mr. C. B. Hoover, Superintendent.

Total gallons of water softened	162,496,000,000
Average per day	21,200,000
Hardness removed, parts per million	26,656,000
Or approximately in grains per gallon	1,600,000
Average hardness removed, parts per million	164
Or average hardness removed, grains per gallon	9.8
Cost of lime	$843,356.98
Average price of lime per ton	$7.60
Cost of soda-ash	$1,639,122.68
Average price of soda-ash per ton	$30.45
Total cost of all chemicals including lime, soda-ash, alum, chlorine and coke	$2,817,976.91
Average cost per year	$134,160.00

Records of operation show that each grain of lime added per gallon reduces the carbonate hardness approximately 12 parts per million and each grain per gallon of soda-ash reduces the non-carbonate hardness approximately 16 parts per million. These figures are corrected to allow for the increase in non-carbonate hardness due to alum treatment. Using the average price paid for lime and soda-ash at Columbus during the past 21 years and the parts of hardness reduced as a basis for computation, the results show:

Pounds of lime per part of carbonate hardness removed per million gallons	12.1
Cost of lime per part of carbonate hardness removed per million gallons, cents	4.6
Pounds of soda-ash per part of non-carbonate hardness removed per million gallons	8.7
Cost of soda-ash per part of non-carbonate hardness removed per million gallons, cents	13.2

Procedure for Reducing Carbonate Hardness.—During the past year at Columbus and for several years at Piqua, O., it has been possible to reduce carbonate hardness to a very satisfactory figure (an average of 30 parts per million for the year and an average of 25 parts per million for the last 4 months of the year was obtained at Columbus) by using the following procedure.*

(1) Use from 25 to 50 parts per million of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium;

(2) Settle out settable precipitates;

(3) Recarbonate with carbon-dioxide gas to the point where the total alkalinity minus two times the phenolphthalein alkalinity equals approximately 5; and

(4) Filter through sand filters.

The following are typical analyses of water from mixing tanks, settling basins and filters:

Water from Outlet of Mixing Tanks	Parts per Million
Total alkalinity	68
Phenolphthalein alkalinity	51
Caustic alkalinity	34
Water from Outlet of Settling Basins	
Total alkalinity	53
Phenolphthalein alkalinity	24
Caustic alkalinity	0
Filtered Water	
Total alkalinity	22
Phenolphthalein alkalinity	11
Caustic alkalinity	0

Low results are obtained even in freezing weather.

The process of recarbonation requires very close supervision, as the carbonate hardness is not reduced satisfactorily if the water is even slightly over or under-carbonated.

Effect of Filtration.—The filtration of this water through sand filters has a bad effect on them because the calcium and magnesium compounds crystallize onto the surface of the sand grains, covering them with an adherent coating which causes them to grow in size and finally to lose their effectiveness as a filter medium. The sand grains not only grow in size, but they also

*Reduction of Carbonate Hardness by Lime Softening to Theoretical Limit, Journal American Water Works Assn., Vol. 21, Sept., 1929.

cement themselves together, forming hard lumps in filters. Once or twice a year it is necessary to spade up those filters and crush all hard lumps, and after seven or eight years of service the filter must be rebuilt.

Outline of Latest Development.—In carrying out the latest development which has been briefly outlined in the first paragraph of this paper, the carbonate hardness is reduced to or practically to the theoretical limit as follows:

(1) Use from 25 to 50 parts per million of lime in excess of that theoretically required to combine with the free and half-bound carbon-dioxide and to precipitate the magnesium;

(2) Settle out settable precipitates (this is preferable but not necessarily essential);

(3) Neutralize excess lime with carbon-dioxide gas ($Ca(OH)_2+CO_2=CaCO_3$);

(4) Mix with large excess of calcium carbonate, sludge produced from water softening reactions or any other inert finely divided material;

(5) Settle; and

(6) Filter.

Results of Latest Method.—For example: A sample of Scioto River water having a carbonate hardness of 144 parts per million was mixed with 11 grains per gallon of quick lime and settled. The supernatant water showed the following results of analysis in parts per million.

Alkalinity to methyl orange	78
Alkalinity to phenolphthalein	61
Excess lime or caustic alkalinity	44

The sample was carbonated with carbon-dioxide gas and then analyzed as follows:

Alkalinity to methyl orange	60
Alkalinity to phenolphthalein	31
Excess lime or caustic alkalinity	2

Calcium carbonate was added (1,500 parts per million), stirred for less than one-half minute, allowed to settle and was filtered through filter paper and analyzed with the following results:

Alkalinity to methyl orange	15
Alkalinity to phenolphthalein	4
Excess lime or caustic alkalinity	0

The novel feature of the process is the addition of calcium carbonate or sludge produced from water softening reactions. The return of sludge has been practiced in water softening, but has never been regarded as of much value, because it is harmful rather than beneficial if water conditions are not right.

Our results indicate that return of sludge is beneficial in reducing the carbonate hardness to the theoretical limit, only when the bicarbonate of calcium has been changed to normal carbonate, the magnesium precipitated to magnesium hydroxide and the caustic or excess $Ca(OH)_2$ neutralized to carbonate. These conditions having been obtained, the sludge not only accelerates precipitation of the finely divided suspended matter but acts as a stabilizing agent as well.

The process is new. It has not yet been tried out on a plant scale.

Results of laboratory tests indicate, that it is going to be a practical process, that the close supervision needed by the present process to obtain uniform and desirable results will not be required, that it will dispense with filtration difficulties and produce water with perfect chemical balance.

Acknowledgment.—The foregoing is a paper presented Feb. 14 at the 8th annual Three Day School at the University of Kansas and 5th annual meeting of the Kansas Water Works Association.

Contractors' Performance Records Studied

Methods of inter-industry co-operation looking toward the elimination of conditions which have made for irresponsibility in the construction industry and the securing of improved surety bonding practices, were outlined at the recent convention of the Associated General Contractors of America meeting, when a report on the work of the bureau of contract information was laid before the delegates.

This bureau was established four months ago at the joint suggestion of the contractors, architects and public officials and is financed by the surety companies of the United States. Its function is to investigate the performance record, past reputation and work on hand of every general contractor in the country. Delegates were told that performance records and contract statements received from contractors in the short time since the bureau was established, have reached a total of well over 1,400. Verification reports have been received from engineers, architects and public officials with respect to 10,161 construction projects. Verifications received from financial institutions total 2,502, and those from manufacturers and distributors of equipment and materials number 8,604. The total received from all sources is given at over 24,000.

The bureau is investigating the performance record, reputation and work on hand of every general contractor in the United States, and questionnaires designed to secure the necessary information are being sent to each contractor. As soon as replies are received, the information given in the questionnaire is verified. Various sources of information are giving their co-operation, the report stated, and verification reports are being received from surety companies, public bodies, engineers, architects, financial houses, manufacturers, distributors and contract reporting agencies.

Meters

No one will take issue with the statement that a measured water is more just, more economical, and more scientific, to both buyer and seller, than any flat or fixed rate that can be devised.

It seems peculiar, however, that there are those who have no objections to buying goods or liquids by weight or measure, but object most strenuously to having the same system apply to water.

The majority of people believe in paying for what they get. To object to the use of a meter is substantially to prefer the methods of antiquity and to oppose modern methods, which years of study and experience have developed. The basis of charge is determined by the quantity furnished, and we believe that is the best and only way.

While no doubt the fact that our meterage as a system is nearing the hundred per cent mark is due to the recognition of water users that it is the only fair and equitable method of payments and shows that the justice of the system has carried its own appeal. We would like to class all metered consumers practically as employees of the Water Department, each serving as inspector on his own premises. If consumers would read their meters often, compare their daily or weekly consumption, leakage would be detected and unpleasant surprises in water charges would be prevented. The commercial and domestic consumption of course depends largely on the personal habits of the people of a community, and to a considerable extent the water used is an indication of the standard of living.

We advise all unmetered consumers to lose no time in having a meter installed. Your monthly statement will show a substantial reduction.—From the 1929 report of W. H. Lawrence, Superintendent of Water Works, Kalispel, Mont.

Central States Sewage Works Association to Meet in June.—The annual meeting of the Central States Sewage Works Association will be held in Springfield, Ill., June 9 and 10.

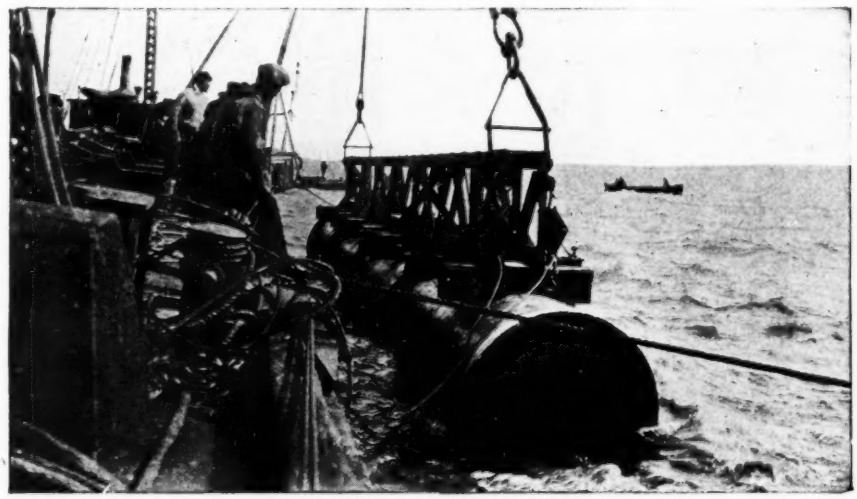
Harry Ferguson, President of the Springfield Sanitary District and chief engineer of the State Division of Sanitary Engineering, Springfield, will handle local arrangements for the gathering. The program now being drafted will include one and one-half days of sessions, at which committee reports and lectures on various phases of sewage disposal problems will be heard. A half-day will be set aside for an inspection trip at the Springfield sewage disposal plant, north of the city.

A 5 ft. Cast Iron Pipe Outfall

Construction Features of the 3-Mile Long Deep Sea Sewage Outlet for Lynn, Mass.

THE city of Lynn, Mass., has completed recently the installation of a 15,300 ft. outlet sewer by means of which the sewage is discharged into the ocean. We are indebted to the March issue of the "U. S. Piper" for the following details.

Preliminary work was done in 1925, but actual construction was not begun until 1926. The outfall project was designed to meet the conditions estimated to occur in 1960, for a population of 170,000. As the two interceptors have a combined capacity at low tide of 60 m. g. d., pumping units for this flow have been provided. In periods of heavy storm, a provision has been made of permitting an overflow into the old outlet in such a way as to prevent this overflow from functioning in periods of small storm and normal flow.



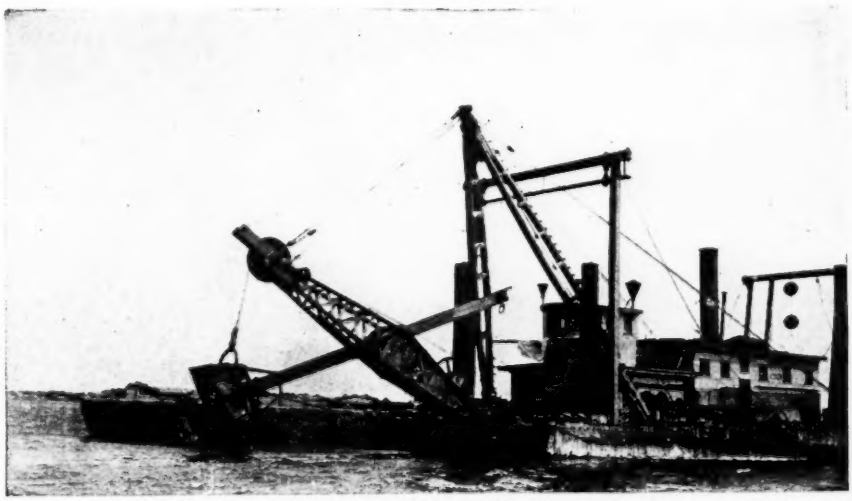
Laying Section of Pipe with "Stiff-Back"

The outfall sewer proper extends from the pumping station near the present outlet, to a point about 3,600 ft. southwest of Bass Point, Nahant. The position of the outlet end was fixed so as to permit laying in as straight a line as possible with no rock excavation.

The material used in this sewer is cast iron pipe 60-in. in diameter. The line extends for 8,500 ft. across the flats with a cover of about 5 ft. The line then passes through a siphon under the federal ship channel for a distance of about 1,200 ft.

This allows a channel 500 ft. wide and 30 ft. deep. From the end of the siphon to the outlet, approximately 5,600 ft., the line is laid at a uniform gradient with about 3 ft. of cover. The actual outlet consists of a 60-in. 30 deg. bend pointing upward and suitably anchored with crushed rock and concrete slabs. Provision has been made for a future siphon in case the harbor development project is consummated.

Dredging the ditch was begun at the channel section and proceeded toward the outlet. A trench 10 ft. wide was dredged to hold the pipe, deep enough to provide the required cover. No rock was encountered so that excavating was not difficult. When the trench across the flats was formed, a channel deep enough to float the barges was dredged alongside the trench thus enabling the work to be carried independently of the tide.



Dredging the Trench

Dredging operations were closely followed by pile driving. Two piles were driven for each bent and two bents were made for each pipe. The piles were driven with a steam hammer and were from 12 to 30 ft. long. The bents were secured to the piles by ¾ in. bolts 18 in. long and were capped with 8x8 spruce timbers. The pipes rested on these timbers and were held in place by wedges nailed to the timber caps. In the places where piles could not be driven because of rock ledges, the bents were installed with built up footings.

The 60-in. pipe were delivered to the Sangus River yards of the Boston & Maine R. R. adjacent to the General Electric Co. River Works. A dock was constructed here by the contractor for loading the pipe onto the barges. The joints used were bell and spigot and four lengths of pipe constituted a section. Sections were made up on the barge and caulked with air hammers. When the barge was in position a "stiff-back" would be securely lashed to a section and the section lowered into place and the joint made up by divers. The cut shows the method by which the section was lowered.

Leakage tests were made after a few sections were laid and these tests were repeated as the laying progressed. Bulkheads were placed over both ends and a vacuum was established. The amount of water leaking in determined the leakage and when 80 per cent of the line had been completed, this leakage was but one-half that allowed by the specifications.

The laying of the outfall sewer was done by the Merritt-Chapman and Scott Corporation of New York City. Morris Knowles, Inc., of Pittsburgh were the Consulting Engineers, with Mr. M. G. Mansfield, Engineer-in-Charge and Mr. E. F. Twomey, Resident Engineer. The borings and soundings were made by B. F. Smith Co. of Boston.

Turbine Type Pump 864 Ft. Long

Water development for California's lucrative citrus crops has had much influence on the building of large pumps. Continued pumping from wells in various localities gradually lowered the subterranean water levels until water production meant lifting 400—or even 500 ft. to the surface. Early in 1929 a record was established when a deep well turbine pump was constructed and installed at Pomona, Calif. The total lifting head from below the ground was 540 ft. In this pump were incorporated many features which make it practical to go to much greater depths.

A turbine pump was recently constructed by the Pomona Pump Co. of Pomona, Calif., by which water is lifted from approximately 850 ft. underground. According to the manufacturers this pump is to be installed in Mexico for the Cia Industrial El Potosi at Zacatecas. The shipment required two railway freight cars and weighed 48,000 lb. without the electric motor.

The illustration shows the driving head and vertical motor to be used. A good idea of its size is gained from comparison with a man and one of the ordinary size driving heads. From the top of the motor to the lowest portion of the pump bowls measures 864 ft. The problem of proper lubrication and prevention of whipping in a drive shaft of such great length was successfully solved by using a water-lubricated resilient type bearing. The shaft floats within a film of water and all vibrations are completely cushioned.

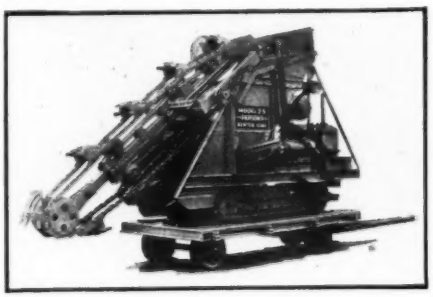
Twenty-five individual pump stages on bowls were used. Twelve of these were installed about 400 ft. underground and the remainder were at the 833-ft. level. Only one shaft is used, as the separate sets of stages drive from the same motor mounted at the surface. The capacity of each set is synchronized. An ingenious regulating device installed immediately below the top group compensated for increase in shaft length as the hydraulic load increased. The impellers have no lower shroud and are adjustable from the surface to compensate for eventual wear.

Driving Head and Vertical Motor of New Pump

The total weight of all moving parts is transmitted to an immense roller bearing in the pump head. This bearing runs in oil, the temperature of which is controlled by water-cooling coils.

New Parsons Ditcher

A new ditcher, the Model 25, for medium sized jobs built according to Parsons patented offset design on full crawler traction has been brought out by The Parsons Co., Newton, Ia. This machine fits right into the Parsons line of patented offset-boom full-crawler machines—coming naturally between the 21, which is designed for lighter trench work, and the 31, which handles the heavier water and sewer jobs.



The New Parsons Model 25 Ditcher

The 25 contains several advanced features which are claimed to be of particular advantage to a machine of this size:

1. Two bucket speeds which, synchronized with the four traction speeds, enable the operator to show large output and save power.

2. Two speeds on conveyor, to adapt it to yardage load at various ranges of digging.

3. Full-crawler mounting on an improved 3-point suspension.

4. Enclosed transmission with ground shafting, heat-treated gearing and roller bearings. This single transmission contains every operation, including traction speeds and reverse, conveyor drive and reverse, boom hoist and reverse, bucket drive and reverse —a compact working unit, fully protected in an oil tight case.

5. Conveyor frame of extra heavy construction, to meet severe digging conditions.

6. Boom hoist through shaft equipped with flexible couplings and connected to pull direct on the roller carrying the boom carriage.

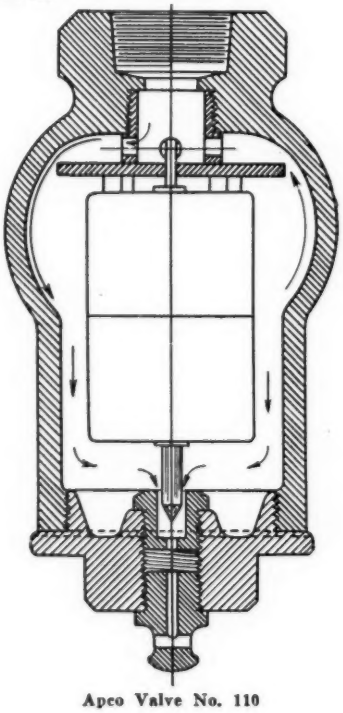
Because of its compactness, the Parsons 25 is easily handled, and easily moved from job to job. Where jumps are long the machine rolls quickly up onto a trailer.

The specifications of the Parsons 25 follow:

Digging widths, 15½ in. to 42 in.
Maximum digging depth, 10 ft.
Digging speeds (inch per minute), 11 in. to 139 in.
Digging speed changes, 16 forward, 4 reverse.
Bucket speeds, two.
Over-all dimensions:
Length when traveling, with longest boom, 27 ft. 6 in.
Length without boom, 16 ft. 2 in.
Maximum height, 11 ft. 8½ in.
Minimum height for shipping, 10 ft. 2½ in.
Width, 7 ft. ½ in.
Width over traction, 5 ft. 7½ in.
Weight, 23,000 lb.
Traction speed (miles per hour), 1.66.
Wheelbase, full parco.
Engine, 4 cyl., heavy duty type, 50 hp.
Conveyor:
Belt width, 20 in.
Maximum height to center line drum, 6 ft. 4¼ in.
Traction:
Tread width, 15 in.
Area, 2,790 sq. in.

Automatic Air Relief Valves

A complete line of automatic air relief valves designed for a wide variety of needs is now being manufactured by the Automatic Primer Co., 111 W. Washington St., Chicago, Ill. These valves are designed to release automatically accumulations of air from pipe lines, pumps and various types of tanks or vessels. They are stated to be simple and compact and to operate continuously without attention. The valves Nos. 50-60-70 are designed for pressures up to 125 lb. per square inch; valve No. 100 is designed for pressures not exceeding 200 lb.; and valves Nos. 110-120-130 for pressures from 250 lb. to 500 lb.



Apco Valve No. 110

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A New Profession, Research Engineering

The opening of a decade serves as a milestone where we should pause to review the economic progress of the preceding ten years. In America what has been the most outstanding economic development since January, 1920? There will be many differences of opinion. We suggest consideration of the rapid increase in the number of research laboratories as being the most important economic development, if not during the past 10, then during the past 20 years.

As we recall it, less than a decade ago "The Chemical Engineer" took the U. S. Steel Corporation to task for not having a research laboratory. Now it has one. This sort of advance has become a common thing among big American corporations. The next decade will probably witness the wide adoption of research methods by American corporations, small as well as large.

In the January issue of "The American Magazine," there is an interview with C. F. Kettering, president and general manager of General Motors Research Corporation. Note the title of that corporation, and bear in mind that it is a subsidiary of the world's largest manufacturer of motor vehicles. Mr. Kettering is a "famous research engineer," to use the designation that appears in that interview. Note also that designation. Ten years ago the title "research engineer" was almost unheard in America. Now there are probably several thousand who claim it.

"In his (Kettering's) laboratories at Detroit he uses his time and that of some 450 physicists, chemists, electrical engineers, mechanical engineers, mathematicians, and mechanics finding fault with General Motors products and thinking up ways to make them better and different."

About 14 years ago we gave the reason why the American Telephone and Telegraph Co. had been able to perfect transcontinental telephony. (See "Inventing an Inventor" in "Engineering and Contracting," Nov. 29, 1916.) That article ascribed the successful solution of that telephone problem to the then novel practice of cooperative research, in which a new combination of brains was devised to solve the problem. The article was widely quoted because of the novel idea that it described—cooperative research.

Cooperative research even 15 years ago was not entirely new in Germany, for several manufacturers of chemical products had well manned research laboratories. But shortly after the world war ended in 1918, when the du Ponts announced that they had organized a research laboratory that employed 3,000 technical men and assistants, there was open-eyed astonishment the world over. How could 3,000 researchers keep busy in any laboratory? That seemed incredible scarcely more than 10 years ago.

Many an engineer is dissatisfied with his economic prospects. To those that have a taste for research and invention, a comparatively new field is open. How to enter that field we do not intend to discuss now.

Many a young man is contemplating taking an engineering course, but is in doubt as to the college to attend and the course to take. We suggest giving preference to a course and a college that offer good training in research methods. Unfortunately few colleges specifically provide such training, for it has been erroneously thought that inventors and discoverers are "born and not made," whereas the fact is that they are born and made. More often than not they are wholly self-made, but this was equally true of civil engineers less than a century ago. The Military Academy at West Point was the first American college to teach any sort of engineering, and it was founded in 1802, "and for about 30 years was the only organized agency for engineering education in America." In 1865 there were fewer than 300 graduates of American engineering colleges exclusive of West Point; yet this country even then had made great engineering progress, largely under the direction of self-made engineers. So it has been with our research achievements up till very recently; but at last it is beginning to be realized that research engineering can be and should be taught as such.

When many young research engineers shall have been graduated, it will not surprise us if their achievements will revolutionize our present educational methods in every branch. After all, a college education accomplishes little that is worth while if it does not train a man to be a systematic, thorough investigator. So even now, the research spirit that is developed at college is the best part of any scientific training received there. However, that sort of training is usually a by-product, whereas it should be the main product, regardless of the degree of native originality of the student or his intended occupation in after life.

Every one of us has at least a modicum of originality. Every one of us is competent to search for and classify information, and the great majority of us can draw correct inferences if we have secured adequate data. Research training develops such native originality as we possess; but even if it failed to do that, it would still be excellent training, for it would habituate men to get the facts and all the gettable facts. Unfortunately, that sort of training is not yet very prominent in many of our schools and colleges.

The Inadequacy of High School Training

Commenting upon the Wall St. panic, an editor urges the teaching of the principles of finance in all high schools. Then, he reasons, there would not be such a large flock of lambs for the wolves to feed on. The suggestion is not without merit, for it has been obvious to those who know how to appraise values that the prices of many securities have long been far above those that their earnings justified. That economic principles should be taught in high schools seems a good suggestion. However, perhaps a better one is that school children should be trained to become habitual searchers for useful information. That they are not so trained is made evident by many facts.

Go into any of the scores of Carnegie libraries, or other public warehouses of wisdom, and inquire the average number of daily users of its books. Compare that number with the population served by the library, and you will quickly disabuse yourself of the illusion that we are an educated people. We are literate, yes; but literary, no. We read, but we study very little after leaving school; and that is simply because we were not trained there to be real students. Instead, we were given a series of rules that we were taught to apply to certain classes of problems, supplemented by a lot of facts that we were required to memorize. While only the slightest effort was made to teach us how to find principles and data useful in solving economic and other problems that confront us in endless sequence after graduation.

Yet a talk with high school teachers will soon convince you that they think they are training their students in the art and science of thinking, and they resent any intimation that their students are primarily memorizers and not thinkers. As for their students being searchers for information, they admit that they are not that, as a rule, but they argue that they will acquire that habit after graduation when the necessities of life force them to search. Well, the records of our libraries prove this last named belief to be an illusion. So, too, do the records of book publishers, for there is scarcely an informative book that should not attain a sale 10 to 20 times what it does reach.

Now we ask: Which is a preferable schooling, one that imparts a large number of economic and scientific principles and data to the students, or one that habituates him to hunt for them? It has long been conceded by educators that the mere teaching of isolated facts is a footless procedure, for facts are infinite in number and of widely varying utility. But it remains for educators to discover that it is almost equally footless to teach most of the principles that they teach. What is a scientific principle? If true it is merely a fact relating to a class of things; the principle of the lever is such a fact. The trouble is that the number of scientific principles and laws is already stupendous, and growing at an amazing rate, so that at best only a very small percentage of them can be learned at school or college. If it be argued that at least the most important principles can be taught there, the question at once arises as to how their relative importance is to be measured. Any careful consideration of this appraisal problem shows that the value of a scientific principle is entirely relative. To most men Newton's all-embracing law of gravitation is almost valueless. Even as engineers, how often do we need to know that the force of gravitation is directly as the product of the masses and inversely as the square of the distance between the centers of mass? Yet here is a principle that has been repeatedly called the broadest, exact generization in the whole realm of nature, for it applies to every particle in that realm and even to the so-called immaterial waves of light. To the astronomer, this law of Newton's is doubtless the most important of all laws. To the civil engineer it is almost valueless, and this statement applies to nearly all scientists other than astronomers. So it is evident that the value of a law or principle is not to be measured by the scope of its application but by the need of applying it in solving problems. Its generality, its admirable simplicity, its beauty may excite our admiration, but like the grandeur of an Alpine peak, it may lack utility and therefore economic value to all but a very few. To most of us, therefore, the law of gravitation is an Alpine peak. And when we carry this analysis farther we soon see that it is a perfectly fruitless endeavor to assign relative values to the different principles of science.

Turning to the other extreme of narrowness of a scientific principle, consider the principle that oil adheres to graphite more tenaciously than to silicates. Such a principle would scarcely be regarded as one to be taught at school, yet it became worth millions of dollars to those who applied it in separating graphite from its gangue.

Not only is the relative value of scientific principles dependent upon the problem in hand, but it often varies enormously within a few years, or even a few days. A principle that is of almost no economic value today may be almost priceless tomorrow if combined with some scientific discovery made tomorrow.

We are driven by such considerations as these to conclude that so far as mental schooling below the college grade is concerned, there should ordinarily be no attempt to teach scientific principles except to illustrate methods of acquiring and applying knowledge, and that the greater part of the student's time devoted to science (including economics) should be spent in searching for information in library and laboratory. Only by years spent in solving problems in which his own resourcefulness is called into play can the average student become sufficiently self-reliant to attempt to solve problems in after life. Lacking such training, the typical high school graduate is a pathetically helpless creature when he emerges into the business or professional world. This is not the worst of it, for the great majority never overcome that helplessness. Having spent eight or more years in routine study that calls for little or no resourcefulness, and having passed the time when habits are formed, the typical high school graduate never develops any resourcefulness, not even that mild kind of resourcefulness that leads him to study what others have discovered, with a view to utilizing their discoveries.

H. P. Gillette

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

The First Hundred Years

ACCEPTING the slogan that "the first hundred years are the hardest" Fairbanks, Morse & Company has successfully reached the top of the hill and may look back over the century with a just sense of pride in its achievements.

Distributor News is very grateful to them for being allowed to look over the proof pages of "The F-M News" and to be able to present to our readers so many interesting notes of the many changes which have taken place in this great organization during this century just completed and to show pictures from "way back when" up to the moment of going to press.

In presenting their story of "A Hundred Years of Fairbanks Scales" in the centennial number of their paper, they use as their lead-off the well known quotation from Emerson: "If a man preach a better sermon, write a better book, or build a better mouse trap than his neighbor, though he build his house in the woods, the world will make a beaten path to his door." And, in condensed form today we say: "Quality counts."

Although Thaddeus Fairbanks, born in 1796, is the first name associated with the company our story is concerned with, the family name goes back in the history of the country almost two hundred years previous to that date, for in 1636 Jonathan Fairbanks built the old homestead in Dedham, Mass., and the old house is still standing as a monument to the enterprise of our first settlers.

The parents of Thaddeus Fairbanks, however, left the established centers of civilization and joined a general movement toward the frontier, which took them, in 1815, to St. Johnsbury, Vt., where for $300 Major Joseph Fairbanks purchased five acres of land with falls rights on Sleepy River. Here Thaddeus, after helping with the building of his father's house, as well as the grist mill and saw mill, began the erection of a mill for the manufacture of wagons, the young Fairbanks first business venture. In 1823, with the wagon business going nicely, Thaddeus opened a small iron foundry, and a year later the business of the mills had grown to such proportions that his older brother, Erastus, gave up the country store he was running to become a partner of his brother. Under the firm name of E. & T. Fairbanks these two young men began the manufacture of wagons, plows and stoves.

Old Homestead of the Fairbanks Family, Built in 1636, in Dedham, Mass., Is Still Standing

In April, 1826, Thaddeus filed his first application for a patent, which was for the exclusive right to manufacture and market cast iron plows, the first of the kind that had, up to that time, been used. While the farmers were slow to use them, declaring that they would soon break to pieces and that further they poisoned the soil, the business grew until now all the world uses them. The business prospered beyond the expectations of either of them, and in 1828 the brothers decided to concentrate their efforts and accordingly disposed of the wagon works and stock at a public sale.

Thaddeus Fairbanks

The active and imaginative brain of Thaddeus was already at work, for about this time he is credited with having invented what was known as the diving flue stove, an important development to improve combustion control, as well as the principle of cooling now generally employed in refrigerators. He secured a patent for this latter, but as he had neither the time nor the money to develop it, he gave it away. In later years the rights in this patent were valued at $1,000,000.

About the years 1829-30 a boom struck Vermont in the form of a craze for raising hemp. E. & T. Fairbanks built several hemp dressing machines and Thaddeus patented an improved dresser and became manager of the St. Johnsbury Hemp Company. The weighing apparatus then used was the old Roman steelyard, suspended in a gallows frame, which left much to be desired, both as to accuracy and ease of operation. So, again the inventive genius of Thaddeus Fairbanks worked out a platform scale, which served the need for which it was produced, but upon which the inventor placed little value, thinking the demand for it would be too limited. But when order after order came for these scales, Erastus saw the possibilities for the use of the new invention.

First came the idea of supporting a platform upon an "A" shaped lever in such a way that the top of the lever could be connected to the steelyard by a rod, then came the idea of two "A"-shaped levers, or with four

straight levers meeting at the steelyard rod, and after working out these plans to his own satisfaction, Thaddeus Fairbanks set out on horseback for Washington to file his patent claims.

This was in the year 1831, the year in which the sewing machine was invented and the year of the first railroad in America, operated by the B. & O. R. R. Many important developments are recorded just prior and immediately following this time, which saw the opening of the Erie Canal, the invention of the friction match, the first successful steam locomotive, the McCormick reaper, the Morse telegraph code and the Daguerreotype. Comments of Mr. Fairbanks concerning his working conditions make interesting reading in these days of up-to-the-minute machine shops: "My plans were all made in the night, frequently working nearly all night on them. For lack of tools the scale work all had to be finished by hand and this, with work on patterns, etc., required all my time during the day in the shops. Faulty work was sure to be sent out unless I was watching all the time; men had to be educated for the simplest operations. There was no uniform machine work as now and it was fifteen years before we had a planer in the shop. Our casting was done in a shed annexed to the old forge, and although we were still in want of funds a larger building was finally put up. It devolved on me to put in the cupola and fixtures, blast, etc., and start operations. I moulded and took the melting often, as there was no other way to learn what caused the unsound stogy places and air blisters that occasionally occurred. In order to teach the men how to make sound castings I had to work several months mixing metals and testing their composition. In making the plans for scales I found there were three things to be considered—the strength of materials, the best shape to secure greatest strength with least material, and the beauty and symmetry of the outside appearance. To imagine what the tastes and notions of men in reference to the right proportioning and beauty of this, then new, article would be, was difficult, but now after fifty years our platform scales are made along the same general design."

If space would permit we should like to tell here the fascinating story of the development of weights and measures from the time of the ancients to the time when the invention of Thaddeus Fairbanks revolutionized these ancient processes and laid the foundation for the scale business of the present day. But this is the story of Fairbanks, Morse & Company, and we have just begun. With the invention of the platform scale the whole attention of Thaddeus and his brothers was concentrated on the development of this business.

The original shop in which the scales were first made was a wooden building 25x60 ft.; it was the factory, warehouse and salesroom combined. The capital invested was $4,000, and there were only ten men on the pay roll. Joseph Fairbanks gave up his law practice to join his brothers and the firm name of E. & T. Fairbanks & Company was adopted. For thirty years Erastus served as business head of the firm and for fifty-five years Thaddeus kept busy drawing plans, designing new scales or modifications and inventing machines for making parts. Joseph was with the firm twenty-two years, and the three brothers were the first salesmen. Most of the correspondence of the early years has been preserved and tells a story of business methods of the times, of scales being rented and also sold on the installment plan, although not called by that name. One conscientious salesman writing from Rio de Janeiro submitted the following: "I am obliged to purchase a dress suit costing $24 on purpose to wear at my audience with the Emperor. I shall probably never wear it again. Shall I add this suit to the bill?"

The Birthplace of the Modern Scale—The Fairbanks Scale Works in 1830

Beside the well established trade in the United States and Canada, the English market was opened in 1835, and trade with China was established in 1846. The story now becomes one of trade expansion and meritorious awards, including foreign decorations conferred upon Thaddeus Fairbanks.

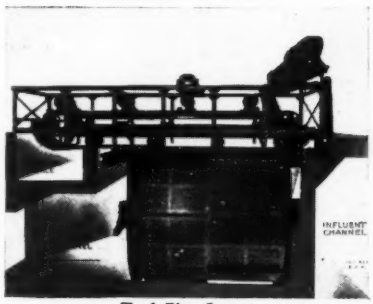
At the time of the Civil War Erastus Fairbanks was governor of Vermont, and many artillery and cavalry supplies were turned out by the factory. The New York branch officials aided Governor Fairbanks in securing requirements for the cavalry and infantry regiments of Vermont. Although the St. Johnsbury plant has always been the largest factory devoting its energies to the making of scales, other products have been added, and electric dynamos were being made and contracts filled for lighting manufacturing plants as early as 1886.

The company was incorporated in 1874, but from the beginning, with its establishment by the three brothers, Fairbanks' sons and grandsons took

The Plant on the Hill—The Williams Engine Works and The Eclipse Wind Engine Co.—1889

LINK-BELT Equipment for Sewage Treatment Plants

Brunotte Bar Screen



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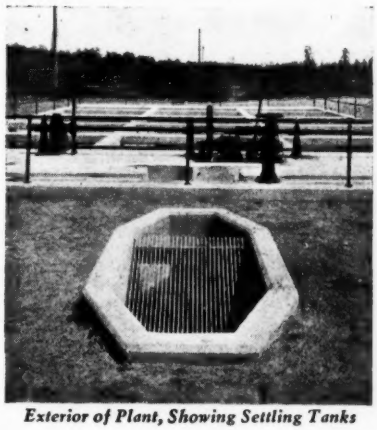
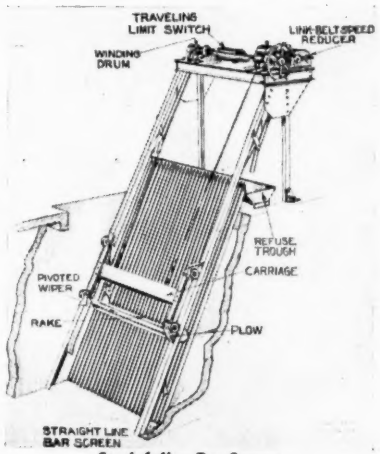


Exterior of Plant, Showing Settling Tanks



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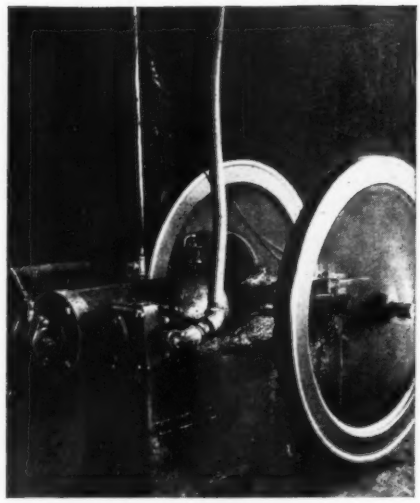
Sewage Treatment Plant Equipment

their places in important positions in the business management, expansion and distribution of the factory products. Franklin Fairbanks, one of the third generation, also had a mechanical bent and many of his inventions were patented. This member of the family had many and varied interests. He was a member of the Vermont legislature, and was active in raising and equipping the first five Vermont regiments during the Civil War. He was a director in several mining companies, and also one of the directors of the Maritime Canal Company of Nicaragua. He was a trustee of Northfield Seminary, Rollins College at Winter Park, Florida, and the Soldiers' Home at Bennington. He gave to his home town the Fairbanks Museum of Natural Sicence. This interest in educational benefactions was another trait in common with Thaddeus Fairbanks, who for twenty years assumed the support of the St. Johnsbury Academy, which the three Fairbanks brothers had founded in 1842. This is the academy, by the way, where ex-President Coolidge received a part of his education. Thaddeus Fairbanks' only son, Henry, also was an inventor, having to his credit some twenty-five patents. The grandson of Thaddeus, Robert Fairbanks, entered the Chicago branch of the company after graduating from college and later became manager of the London house.

As early as 1870 a noted English writer characterized the town of St. Johnsbury as a "workingman's paradise." Some of the reasons for this expression may be found in a quotation from the "American Centenary" in 1876, in writing of the firm of E. & T. Fairbanks & Company: "These men have always displayed the most generous and judicious spirit of liberality and kindness towards those whom they employ, providing means for their mental, moral, religious and esthetic culture, in a way that makes their establishment a model one. They have provided for scientific lectures; created a lyceum; established free schools; a free library and reading-room; and a free art gallery with suitable buildings for



One of the Earliest Gasoline Engines, Fairbanks-Charter Engine Installed in 1898 is Still Running

all. * * * There is not, probably on the face of the earth, a community of working people who enjoy so much solid comfort as these. The proprietors and workmen regard each other as mutual friends."

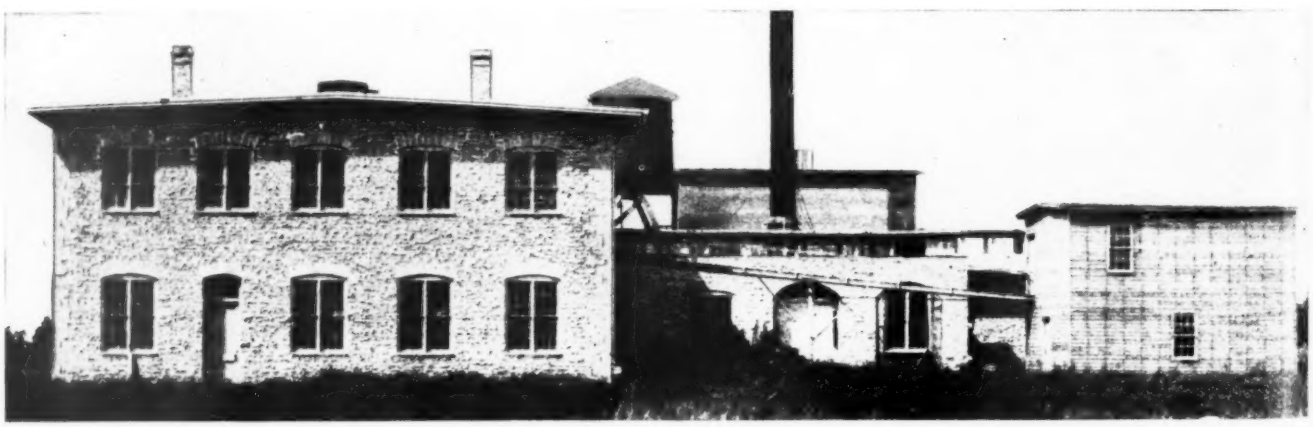
To refer once more to the expression used at the beginning of this story "quality counts," possibly it would be better to change it to "accuracy counts," for the chief concern of every one connected with the St. Johnsbury plant is for accuracy, the whole prestige of the scale being based on this one characteristic.

Up to this point in the story the only firm name referred to has been the E. & T. Fairbanks Company, but the history of this organization is really divided into two phases, the E. & T. Fairbanks & Company phase and the Fairbanks, Morse & Company phase, the first centering around Thaddeus Fairbanks and his inventions and the second around the life of Charles Hosmer Morse, who became a part of the history of this company when he went to work for it in St. Johnsbury at the age of seventeen, having been born there three years after the invention of the scale. This seventeen year old boy apprenticed himself to the company for three years at $50 a year. Later as an advancement he was sent to New York where, according to the story, soon after his arrival he sat down on a curbstone and fought a battle of homesickness, pondering whether to turn back or go on. He did not turn back then nor thereafter.

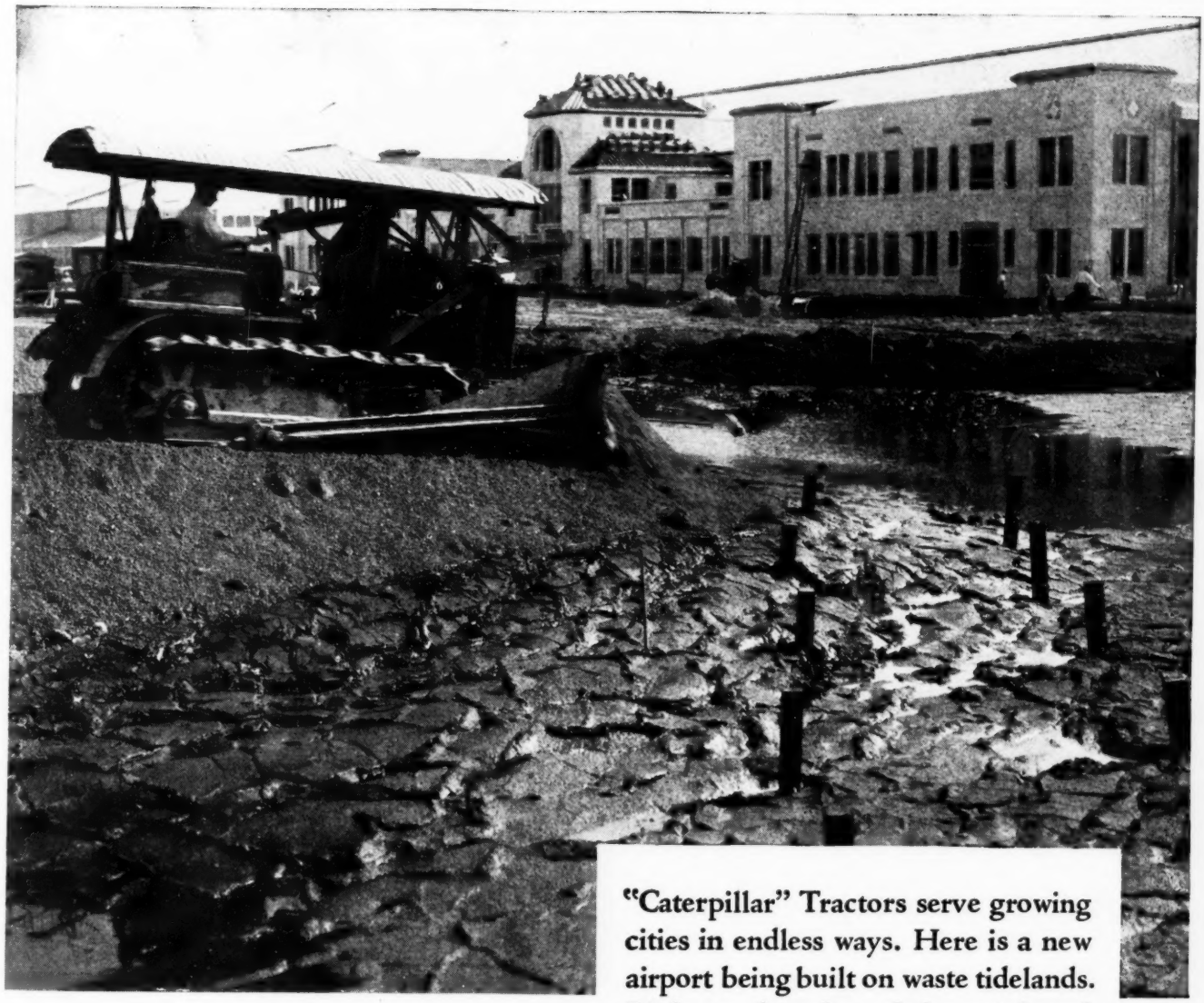
He entered the St. Johnsbury factory in 1850. In 1857 he was transferred from New York to the Chicago office, and in 1865 he went to Cincinnati to establish the first branch of the business to be known as Fairbanks, Morse & Company. A second house under the same name was opened the same year in Cleveland, and then followed offices at Pittsburgh and Indianapolis, although the Pittsburgh office was later transferred to the Fairbanks Company.

Up until 1870 the Chicago branch of the business was known as Fairbanks, Greenleaf & Company, but owing to the failing health of Mr. Greenleaf, Mr. Morse was called to the Chicago office and was admitted into partnership of this company. At the time of the Chicago fire the store was located on State St. near Madison St., and with other business houses was entirely burned out. The partially charred records of the company were taken from the cellar of the building and by careful handling and the aid of loyal customers accounts were made out and settlements made, and the firm of Fairbanks, Greenleaf & Company, as such, ceased to exist. The Chicago fire started on Sunday night, continuing until after nightfall Monday. On Tuesday morning a small store and basement on Canal St., untouched by the flames, was opened for business as Fairbanks, Morse & Company. Here with kitchen tables and chairs for office furniture and more orders than goods, anxious customers were cared for. As soon as new quarters were available Fairbanks, Morse & Company moved to Washington St., and then followed one or two other moves, until the year 1908, when they located in their present offices at 900 S. Wabash Ave.

With the transfer of Mr. Morse to Cincinnati to serve territories sparsely



The Beloit Wagon Works in 1880, the Foundation of the Present Beloit Plant



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settled, he cast about for other lines to sell in order to keep down the overhead necessary to maintain an efficient sales force. He opened a factory in Cincinnati in 1866 for the manufacture of letter and waybill presses and warehouse trucks. Just about this time the Reverend Leonard H. Wheeler brought out the first hinged vane windmill. Dr. Wheeler had an Indian mission in Wisconsin which he moved from Ashland to Beloit in 1867, and on the advice of friends took out patents on his windmill. Here with his sons he conducted a rapidly growing business in windmills. In 1880 Mr. Morse secured the sales agency for this product and this formed the first step in the association from which has grown the large Beloit plant of Fairbanks, Morse & Company. When the windmill company was incorporated in 1881 as the Eclipse Wind Engine Company, Mr. Morse secured an interest in the business for Fairbanks, Morse & Company.

The business at the Beloit plant proved so profitable that more space was needed for manufacturing and the Eclipse Wind Engine Company bought the plant "on the hill," then known as the Beloit Wagon Works, and the site of the present factory. It was in this first plant that Fairbanks, Morse & Company began their association with the engine business. Mr. W. H. Wheeler, president of the Eclipse Wind Engine Company, and a son of old Dr. Leonard, the windmill inventor, together with Mr. Morse and Mr. E. F. Williams, formed a corporation known as the Williams Engine Works, to promote the sale of a steam engine with which Mr. Williams had been experimenting. The citizens of Beloit, realizing the advantages of retaining a manufacturing establishment of this kind, donated $10,000 and ten acres of land to the new company, thus bringing the total acreage of the two companies up to forty-one.

The lines developed at Beloit included windmills, tanks, pumps and hoisting engines, and when the Chicago Arc Light & Power Company, in 1890, installed in their plant three 500-hp. tandem compound engines, these were

C. H. Morse.

the Williams engines made at Beloit. All the transmission equipment was furnished at that time by the Eclipse Wind Engine Company. This large Chicago company came under the management of Samuel Insull in 1892, which soon became the Chicago Edison Company, and later the Commonwealth Edison Company. While Fairbanks, Morse & Company had been selling pumps for sometime, they were first made in the Beloit plant, when a line of steam pumps was brought out in 1891. Later several other types, including the gear-driven and centrifugal pumps, were added, making the line quite complete.

The agency for hand cars of the Sheffield Velocipede Car Company of Three Rivers, Mich., was taken over by Fairbanks, Morse & Company in 1883, and by 1895 experiments were being conducted to perfect a light gasoline engine to be attached to the three-wheeled car, in order to secure a self-propelled type of car, which at that time had never been built. This led to other railroad products, including standpipes, water towers and tanks, coaling stations and always scales, a line with which Mr. Morse never lost close contact.

The Deisel engine business of the company was started about 1893, when Mr. Morse engaged the services of James A. Charter, who had brought his drawings and patterns of gasoline engines to the Beloit plant. He had been associated with his father, John Charter, for some time in the development of the gasoline engine, and their first patent on this type of prime mover is dated Sept. 12, 1887. The first engines built at Beloit were of the four-cycle type, and in 1895 the first small vertical engine appeared. From this time on followed a period of rapid development in motive power, up to the present-day line of ball bearing motors, another field in which Fairbanks, Morse & Company pioneered.

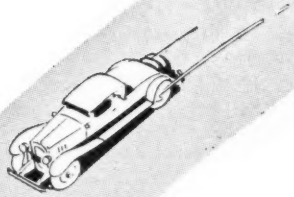
Development of a line of pumps was started in the late '70s, beginning with the Eclipse double acting, vertical cylinder force pumps which were used with the Eclipse windmill. Pumps of various design were built as the demands arose. These included the direct acting steam pump, the geared design, centrifugal pumps and the Wood trash pump and Price deep well pump.

At this time the plant at Three Rivers, Mich., handles the output of Sheffield cars, wind mills, pumps and railroad equipment. Beloit is devoted to the gas and oil engines, including the generator for the Deisel electric sets and the new line of synchronous motors which are closely allied with the generator. The Indianapolis plant is devoted exclusively to the manufacture of electric motors, and scales continue to be made in St. Johnsbury and East Moline, Ill.

As territory after territory was opened up in the pioneer days, Mr. Morse established branch after branch for his great company, until there are now thirty-one branch offices in the United States alone. The Canadian Co. was established in 1908 at Sherbrooke, on property donated to the E. & T. Fairbanks Company. The Canadian

The Beloit Works of Fairbanks, Morse & Co. as It Appears Today

IMPROVE YOUR OLD ROADS



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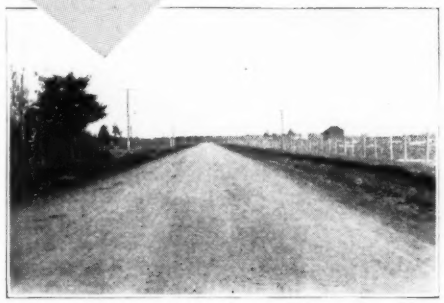
Mail the coupon below for specifications and full information.



Minnesota State Highway. Treatment of subgrade with Standard Asphalt Road Oil. Note smooth, dustless surface which is in good condition throughout the year.

South Dakota Highway. Three inches of gravel being treated with Standard Asphalt Road Oil by the mixed-in-place method. This method insures a durable, year'round riding surface.

Linn County, Iowa, September, 1929. Stanolind Cut Back Asphalt retread just after the keystone has been applied. This method of road improvement is an economical way of salvaging your old road bases.

Four proven road treatments, one of which will fit into your road surfacing program

Preparing Sub-grade with Standard Asphalt Road Oil prior to the application of gravel. When subgrades are treated by this method and covered with 350 cubic yards of gravel per mile, the asphalt road oil does two important things: it holds the gravel in place, and waterproofs the subgrade.

Mixed-on-the-Road Method. An untreated gravel road carrying 500 cars a day loses approximately an inch of surface a year through dust, which is costly waste. You can treat three inches of this gravel by the mixed-in-place method as cheaply as you can maintain the gravel road. When Standard Asphalt Road Oil is specified, the surface obtained will be hard and smooth the year 'round.

Surface Treating of Hard Surfaced Roads, such as compacted gravel, crushed rock and other hard surfaces, with Stanolind Cut Back Asphalt is an economical way of maintaining these roads. It entirely eliminates dust and cutting up in bad weather.

Stanolind Cut Back Asphalt Retread (or mixed-in-place method) is a practical method for building a wearing surface on present road bases. This type of road is easily and quickly constructed. It is non-skid and durable. The cost comes within that of building standard low cost improved roads.

Standard Oil Company
(Indiana) 226

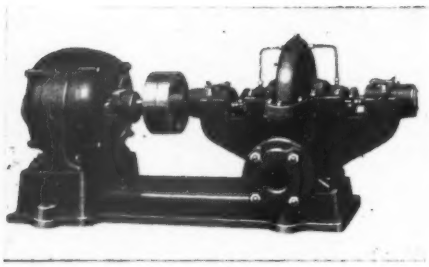
Standard Oil Company *(Indiana)*, Room 1219
910 South Michigan Avenue, Chicago, Illinois
You may send me specifications and plans for improving secondary roads with Asphalt Road Oil and Cut Back Asphalt.

Name _____

Address _____

City _____ State _____

Asphalt and Road Oil for Low Cost Improved Roads



Centrifugal Pump and Direct Connected Motor Products of the Three Rivers and the Indianapolis Palnts

company is now called the Fairbanks, Morse Co., Ltd.

Mr. Morse was visionary yet practical, thrifty but generous, conservative but progressive, and his policy of always maintaining sufficient capital at hand to take advantage of any sales possibilities was responsible for many of his most successful developments. On his death, in 1921, his son, C. H. Morse, became president of the company, a position he held until his election to the chairman of the board of directors. At that time R. H. Morse was made vice-president of the board of directors and W. S. Hovey was elected president of the company.

Mr. Hovey, who was born in 1875 and is a graduate of Cornell, joined the Sheffield Car Company in 1902, as assistant superintendent. In 1913 he was transferred to the Beloit works as manager of the engine division. In a few months following his transfer he was made general manager of the plant. In 1919 he was elected vice-president in charge of all manufacturing activities, and 1924 was made general manager of the entire business.

Due to the high type of products and efficient marketing organization this company now does an annual business in excess of thirty-three million dollars, and the original investment in the scale business in 1830 was $4,000.

Dr. James Aston Awarded Robert W. Hunt Medal

At the annual dinner of the American Institute of Mining and Metullurgical Engineers, held recently in New York City, the Robert W. Hunt medal was conferred upon Dr. James Aston, director of mining and metallurgy at the Carnegie Institute of Technology, in recognition of his paper on "A New Development in Wrought Iron Manufacture."

Dr. Aston is consulting metallurgist of the A. M. Byers Company of Pittsburgh, and his method for quantity production of wrought iron is known commercially as Byers' New Process, because of its adoption by that company, which is now building a $10,000,000 plant for its utilization just below Ambridge, Pa.

The paper deals with two years of observation and experience in the commercial production of the new process wrought iron at the Byers' plant at Warren, O. Its emphasis is placed on the practical rather than the theoretical phase of the process.

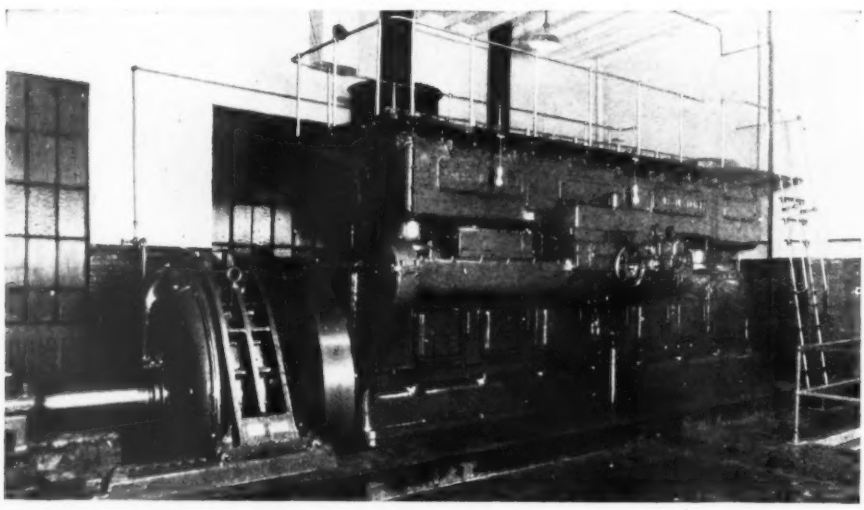
"The process," writes Dr. Aston, "is divisible into several steps, which correspond to and parallel the major subdivisions of the hand puddling method."

Dr. Aston presented the various steps of the process covering, melting, refining, disintegration of the metallic mass, the pouring and intermingling of the spongy mass of metal with liquid slag, etc. Many investigators, Dr. Aston states, including the Bureau of Standards and other government as well as marine and railroad representatives have found that the material conforms to all standards set for wrought iron, chemical, metallographic and physical.

"There is a benefit in the added work put upon the larger mass," Dr. Ashton says, "uniformly low content of carbon in the blown metal has resulted in virtual elimination of blisters, the bane of wrought iron manufacture. Low metalloid content, and particularly the controllability and adjustability of metal and slag character independently, has benefited the welding and other physical properties of the product. In addition, this operating advantage points the way to the manufacture of wrought iron of special characteristics and adaptibility, including the possibility of entry into the alloy field.

The paper concluded with an outline of the new plant being built for the A. M. Byers Company, where the balls will be about two tons in weight. He says: "A more rapid operation will be obtained by a cup-car system of handling, with progressive movement of the cars to the several zones. Initial production will be 600 gross tons per day, with only minor extensions to double or treble this output. Immediate mill equipment will be blooming, plate, bar and skelp mills; with projected extensions to include blast furnace and coke oven plant and finishing mills.

In concluding Dr. Aston states: "This project should put wrought iron into proper place in the field of ferrous products, through an expanding market made possible by lowered costs, greater tonnages and diversification of output."



One of the Latest Fairbanks-Morse Diesel Generating Units Installed in a Semi-Isolated Public Utility Power Plant

House Magazines*

Editor's Note: This column is published every now and then. Many most attractive and interesting house magazines come to our desk from time to time, and we take this method of acknowledging them.

Sauerman News in the February issue carried a very interesting story of the new plant of the Beyrer Bros. Sand & Gravel Company at Mishawaka, Ind. This booklet is always so well illustrated and contains so many items on the uses of scrapers and cableways that any one with excavating and material handling problems would find it of great interest.

The U. S. Piper, now in its third volume, continues to be a most attractive quarterly on cast iron pipe and its applications. The March issue has a very interesting story on the Albany Water Supply, starting back with the service this city enjoyed from Revolutionary times, and containing many historical points of interest. The Piper is published by the U. S. Pipe & Foundry Company of Burlington, N. J., and edited by Ralph M. Shaw, Jr.

The Power Specialist is the monthly paper of Johns-Manville Company of New York City. A brief editorial on "The Worker, Give Him a Chance to Use His Mind" contains a constructive idea for all manufacturers who have not already made use of the Suggestion Committee Plan. Insulation problems, engineering innovations, corrosion troubles and questions of distribution are all touched upon in the February issue.

*Manufacturers named will be pleased to send above mentioned publications to readers upon request.

THE MOST IMPORTANT INGREDIENT IN YOUR PIPE COATINGS IS

EXPERIENCE

The best solution to any of the problems that come up in the business of coating pipes is knowledge. Robertson has the knowledge. The H. H. Robertson Co. is the world's largest producer of special asphalts. It has made investigations in the action of soils on coating materials. It can determine the exact combination of asphaltic bases that are best calculated to protect your pipe under any given set of conditions . . . and it can produce exactly that combination.

Specify Robertson coatings on your pipes.

H. H. ROBERTSON CO.,
PITTSBURGH, PA.

ROBERTSON HAS THE EXPERIENCE

GOLDEN-ANDERSON

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

Adapted to automatically maintain a uniform water level in feed-water heaters, tanks, reservoirs, and pans. Very sensitive.

Operating on ½-in. to ¾-in. variation. No exhaust or expensive water waste. Can be furnished for hot or cold initial water supply. Reliable and dependable under varying pressure.

Sizes ½ in. to 24 in.

Automatic "Cushioned" Controlling Altitude Valves
Cushion All Water Surges

Automatically maintains a constant stage of water in reservoirs, tanks and standpipes. They do away with the annoyances of Freezing Valves and Float fixtures inside of the Tanks or Floats and Fixtures outside of Tanks. "Three Ways of Closing These Valves."

1st—Automatically, by water.
2nd—By electricity, if desired.
3rd—By Hand.

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe.

The double cushion effect of air and water eliminates water hammer. There are no dangerous surges to burst water mains. **Write for details.**

REMEMBER Valves cushioned at all times by air and water. No water hammer or bursting mains.

"Made with stop starter attachment for centrifugal pumps."

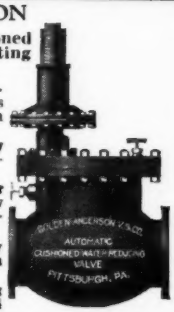
Golden-Anderson Valve Specialty Co.
1385 Fulton Bldg., Pittsburgh, Pa.

GOLDEN-ANDERSON
Patent Cushioned Water Relief Valves

1. Automatically relieve excess pressure.
2. Prevent stress, strain and bursting of mains.
3. Correct mechanical construction.
4. Perfect air and water cushioning.
5. No metal-to-metal seats. No hammering or shocks.
6. Angle and globe pattern. Sizes 3 to 24-in.

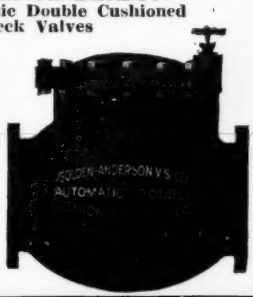
GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required—No attention necessary.
5. Positively no hammering or sticking. Sizes to 24 in.



GOLDEN-ANDERSON
Pat. Automatic Double Cushioned Check Valves

1. Especially adapted for Water Service.
2. For High or Low Pressure.
3. Thoroughly Cushioned. No Chattering, Hammering or Sticking.
4. Globe or Angle Patterns up to 24 in.
5. Especially adapted for hydraulic elevator service.



GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipe, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle—Most Satisfactory Float Valves known.
4. No Metal-to-Metal Seats—No Water Hammer or Shock.
5. Cushioned by Air and Water.

Sizes ½" to 24".

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Distributor thoroughly familiar with bituminous materials and equipment for handling, wishes to add to present lines. Covers Wisconsin and Illinois territory.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

Distributor covering New Jersey and New York territory would like to secure a line of street markers or other traffic equipment on exclusive basis.

Equipment distributor in Pacific Northwest desires line of road building equipment, structural building equipment, dump bodies and truck hoists.

Distributors of contractors' and builders' machinery and equipment are seeking line of road forms, road finishers, batcher plants, clamshell buckets and drag line buckets, for northern California terirtory. Now stocking equipment for several well known machinery manufacturers.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Road machinery distributor would like to secure exclusive sales rights for state of Mississippi for line of automatic or self-loading wheeled scraper.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Equipment distributor located in Michigan desires to add two or three good lines to serve territory in southeastern part of state.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Machinery distributor established in Porto Rico and Santo Domingo would be pleased to make arrangements to take on new lines in these territories.

Machinery company in the east is interested in representing established lines of road machinery, with the exception of graders.

Representatives Wanted

Manufacturer of cut to length, easily erected standardized steel highway bridges, for spans up to and including 40 feet, which are sold to highway commissioners and superintendents, has attractive territory open in states south and west of Chicago.

Manufacturer of Transverse Testing Machines desires to build up distribution organization in this country and abroad.

Manufacturer of plows, grade-rippers and scrapers desires representation in Arizona, New Mexico, Arkansas, Kansas and Louisiana.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of paving expansion joints is seeking distributors and manufacturers' agents in good, unassigned territory.

Manufacturer of air compressors and contractors tools has number of desirable territories open. Full co-operation will be extended to distributors.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of hoisting machinery and air compressors has open territory in New York and New England states for aggressive distributor.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

A manufacturer of paving expansion joints is looking for distributors for northern California territory.

Manufacturer of metal lath, corner beads, channels and reinforcing mesh desires to secure distributors for products in the southwest and middlewest.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Manufacturer of mechanical spreaders for cover material desires representation by organizations covering entire states. Several desirable states are still open. Number of inquiries now on hand for spreaders require immediate follow up.

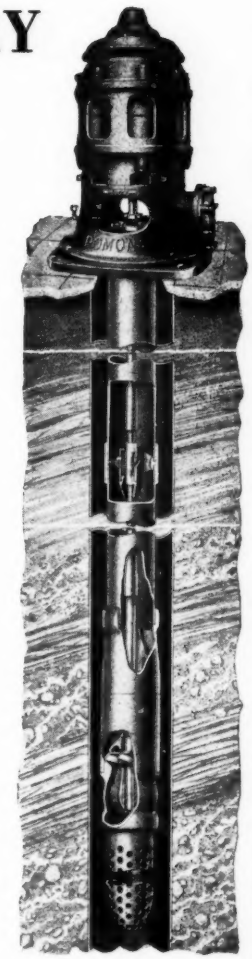
Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

POMONA PUMPS
Oceans of Water

Cleanest WATER

FOR EVERY NEED . . .



Ample quantities of clean water produced for any desired purpose. Greatest pumping economy permanently maintained. The Pomona Water-Lubricated Turbine Pump is the ultimate in pumping equipment, designed for modern needs. The pump is entirely water lubricated below the surface of the ground. Impellers are of the open bottom type permitting variation of pumping capacity by means of an adjusting nut mounted on the top of the motor at the surface. Capacities up to 5000 gallons per minute furnished for all sizes of drilled wells or for sump service. Let our engineering department furnish you with complete specifications to meet your pumping needs. Write for bulletins fully describing this modern pumping method.

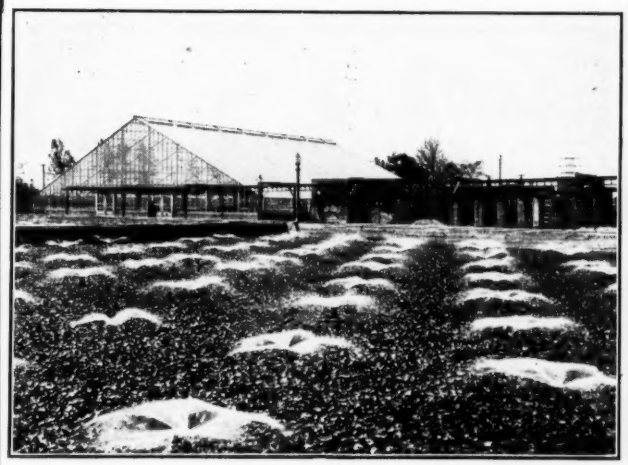
Write for name of nearest distributor or factory representative located in all principal cities.

POMONA PUMP CO.
Pomona, California

PERMANENTLY DEPENDABLE

Outgrown Sewerage Disposal

—made adequate by KING



King Glass-Enclosures for Sludge Beds Increase Plant Efficiency 3 Times

King Sludge Bed Enclosures offer a practical solution for the problem facing so many communities; outgrown sewerage disposal. For by trebling the capacity of the present sludge beds through year-round operation, these enclosures make it possible to accommodate three times the present population. No need to enlarge the plant, or increase the area.

There are many other advantages. King Enclosures, appealing in design, revolutionize the appearance of disposal plants, making them attractive and welcome in almost any community. And by means of controlled ventilation, the objectional odors (so common to sludge drying) are practically eliminated.

Let us tell you all the facts about the efficient service and sturdy construction of King Enclosures.

OUR CATALOGUE IS FILED IN SWEET'S

KING CONSTRUCTION COMPANY
533 Wheatfield Street
North Tonawanda, N. Y.

New York City · Philadelphia, Pa. · Boston, Mass.
Scranton, Pa. · Toledo, Ohio
Schenectady, N. Y. · Bridgeport, Conn.

Leonard W. Saine Succeeds Robert W. Conrow

Leonard W. Saine

The Central Foundry Company announces the appointment of Mr. Leonard W. Saine as General Manager of Sales for Universal Pipe Division.

Mr. Saine, who was the Company's representative in the South for a number of years, succeeds Mr. Robert W. Conrow. Mr. Saine will make his headquarters at the general offices of The Central Foundry Company, Graybar Building, Lexington Ave. and 43d St., New York.

A. M. Byers Increases Sales Force

Mr. L. M. Johnston, vice-president of the A. M. Byers Company of Pittsburgh, announces that in order to meet the growing demand for wrought iron piping it has been necessary to increase the personnel of the Byers sales organization. Mr. Johnston announces the following appointments:

D. S. Sampson assigned to the New York office, under Division Manager G. W. Hamill, to cover New Jersey territory.

R. C. Hamlett assigned to New Orleans, under jurisdiction of Division Manager A. D. Sheere of Atlanta.

Irwin P. Young, with headquarters in Chicago, under Division Manager M. G. Henderson.

T. D. Graham to St. Louis territory, under Chicago Division Manager M. G. Henderson.

About the Cement Institute

The Cement Institute is an association of manufacturers of Portland Cement, with general offices at 11 East 44th St., New York, N. Y.

The Purposes of the Institute, as set forth in the Articles of the Association, are as follows:

To promote the best interests of the cement industry by providing facilities for collecting, through voluntary action, information with respect to trade and commerce therein, and disseminating such information among the members of the Institute and the public generally. The information, so collected and disseminated, shall be as follows:

(a) Information concerning credits.

(b) Information concerning actually closed specific job contracts and other contracts for the future delivery of Portland Cement.

(c) Information concerning production and stocks on hand of clinker and Portland Cement and shipments of Portland Cement, and cloth sack returns.

To collect and disseminate such other and further trade information as the Institute may determine upon from time to time in accordance with the provisions of these Articles of Association.

To adopt and promulgate a Code of Ethics for the government of the members.

To establish and maintain all such lawful trade customs and usages for the protection of the members as the Institute may deem advisable.

To adopt lawful plans for the general development and improvement of the industry.

Any person, firm or corporation regularly engaged in the manufacture and sale of Portland Cement is eligible to membership.

The officers of the Institute are:

President—Blaine S. Smith, President Pennsylvania-Dixie Cement Corp.

Vice President and Treasurer—Morris Kind, President Hercules Cement Corp.

Vice President—M. C. Monday, President Hermitage Portland Cement Co.

Vice President—Chas. Irvin, Vice President Alpha Portland Cement.

Vice President—J. A. Lehaney, Vice President and Manager Lone Star Cement Company (Kansas).

The above officers, together with the following, are members of the Board of Trustees:

G. S. Brown, President of the Alpha Portland Cement Company.

George F. Coffin, Treas. and Gen. Mgr. Nazareth Cement Co.

Charles Schmutz, Vice President Bessemer Cement Corporation.

Col. E. M. Young, President Lehigh Portland Cement Company.

In addition to this New York office, the Institute has offices at present in Chicago, Illinois, and Kansas City, Missouri.

Col. Wm. J. Donovan is counsel for the Institute.

Luther G. McConnell is General Manager of the Institute.

George H. Reiter is Manager of the Chicago Division and Baxter D. McClain is Manager of the Kansas City Division.

Du Pont Technical Division Holds Annual Meeting

The 14th annual meeting of the Technical Section of the Explosives Department, E. I. du Pont de Nemours & Company, was held recently in the du Pont-Biltmore Hotel, Wilmington, Del. Arthur LaMotte, manager of the section, presided. More than one hundred subjects relating to explosives and their uses in mining, construction and for other industrial purposes were discussed by the eighty du Pont executives and field representatives from all parts of the United States.

J. W. McCoy, general manager of the Explosives Department, addressed the opening session, while L. P. Mahony, director of sales, was the principal speaker at the dinner which followed the close of the three-day meeting.

Edward R. Bacon Company Resumes with Byers Lines

The Byers Machine Company, Ravenna, O., announces the appointment,

Mr. Edward R. Bacon, President Edward R. Bacon Co.

effective immediately, of Edward R. Bacon as its sales representative in San Francisco and northern California. The Bacon Company will handle the entire Byers' line, including ½ yd., ¾ yd., 1 yd. and 1¼ yd. shovels, cranes, draglines, trenchers and skimmers.

W. R. Macatee District Engineer for Cement Association

The Portland Cement Association announces the appointment of Walter R. Macatee as district engineer in charge of association work in the states of Virginia and North Carolina, with offices at 904 E. Main St., Richmond, Va.

For several years past Mr. Macatee has been engaged in road promotion throughout the southeastern states. During 1926 he was in charge of district office at Jacksonville, Fla., later going to New Orleans.

Mr. Macatee is a native of Virginia and served as captain in the marine corps in the World War.

New Detroit Quarters for Cutler-Hammer

Effective Feb. 10 the Detroit district sales office of Cutler-Hammer, Inc., pioneer manufacturers of electric control apparatus, will be located at 2755 E. Grand Blvd., Detroit, Mich., according to announcement issued from the home office at Milwaukee, Wis.

The new location includes warehouse facilities where stocks of standard C-H motor control, wiring devices, safety switches and other C-H products will be carried for immediate delivery.